2002-01-01

Fear of Fatness Among Young Irish Adolescents : Association with Obesity, Reported Iron and Folate Intake, and Dental Health

Anne C. Griffin
Technological University Dublin

FEAR OF FATNESS AMONG YOUNG IRISH ADOLESCENTS: ASSOCIATION WITH OBESITY, REPORTED IRON AND FOLATE INTAKE, AND DENTAL HEALTH

by

Anne C. Griffin
B.Sc. (Human Nutrition), Dip. (Nutrition and Dietetics)

A thesis presented towards a Doctoral Degree (*PhD*)

At
The Dublin Institute of Technology
School of Biological Sciences

----July 2002----

Supervised by:

Dr. Mary A.T. Flynn, Healthy Communities, Calgary Health Region, Alberta, T2T 5TI, Canada

Dr. Katherine M. Younger, School of Biological Sciences, Dublin Institute of Technology, Kevin St., Dublin 12

Prof. Michael J. Gibney, Department of Clinical Medicine, Trinity College, University of Dublin, Dublin 2

DUBLIN INSTITUT
of TECHNOLOGY
Institiúid Teicneolaíochta Bhaile Átha

DIT Kevin Street, Dublin 8, Ireland
DIT Shráid Caoimhín, Baile Átha Cliath 8,
Tel: +353 - 1 - 402 3000
Fax: +353 - 1 - 402 4999

To whom it may concern,

I certify that this thesis which I now submit for examination for the award of Doctoral Degree (PhD), is entirely my own work and has not been taken from the work of others save and to the extent that such work has been cited and acknowledged within the text of my work.

This thesis was prepared according to the regulations for postgraduate studies by research of the Dublin Institute of Technology and has not been submitted in whole or in part for an award in any other Institute or University.

The Institute has permission to keep, to lend or to copy this thesis in whole or in part, on condition that any such use of the material of the thesis be duly acknowledged.

Signature__________________ Date 30/05/2002

Candidate

n

To

shap

Thank

College,

my coll

tal Hosp

For a continued interest in progress and development, the Department of Biological Sciences, including Bríd Ann Ryan, Mary Moloney, Joe Vaughan, Helen Casey and Stephanie Mulgrew.

Yvonne Ryan and Marie Cantwell for all the initial do's and don'ts when I started out.

As a source of unexpected interest and support, Ita Saul and her staff at the Department of Nutrition and Dietetics, Our Lady's Hospital for Sick Children, Crumlin.

Thank you to my unsuspecting guinea pigs who allowed me to practice drawing blood samples on their poor fingers, Sheena Ruane and Donal O'Connor and most especially Irene and John Kerin….thanks guys!!!

And finally but by no means least, the most important people who ultimately kept the ball rolling and put up with all the moaning: My parents, John and Mary, my sisters, Barbara and Deborah, my boyfriend Cormac (Ninety) and my best friends Cecilia, Ruth, Damien, & baby girl Ciara, Sharleen, Tanya, Hilary, Emer, Karl and Kinda, and Pat, Mary & Maeve Falvey.

Thank you.

Table of contents

Abstract.

OBJECTIVE: To establish the prevalence of fear of fatness (the desire to be thinner) and associated factors, including obesity, reported energy, iron and folate intakes. The difficulties in defining overweight among Irish children and an assessment of dietary and socio-economic factors related to dental caries are also reported in the group. METHODS: A one-year follow up study of 251 healthy schoolchildren at baseline (119 boys and 132 girls; mean age 11 years) attending 7 fee-paying (6 single- and 1-mixed sex) and 8 non-fee-paying (4 single- and 4 mixed-sex) schools in Dublin city center. Assessment of body image perceptions and satisfaction (using figure line drawings) and toothbrushing habits were reported in questionnaires specifically designed for this study. Nutrient intakes and the amount and frequency of cariogenic foods were estimated from two-day food diaries kept on two occasions over a three-week period. Weight, height, triceps and subscapular skinfolds were measured and used in several definitions of overweight, which included Body Mass Index and Actual Relative Weight cut-offs.

RESULTS: Significantly more girls than boys (39% vs. 17%) and more overweight children were affected by fear of fatness. Girls were twice as likely as boys to report trying to lose weight (42% vs. 20% at baseline, and 41% vs. 21% at follow up). Overweight (BMI $\geq$26kg/m^2) has increased 5-fold among boys and 2.5 fold among girls over the last ten years. The prevalence of overweight differed by 9% at baseline and 8% at follow up depending upon which method of weight status was used. A high prevalence of under-reporting energy intake (39% at baseline and 50% at follow up) was found and associated with a desire to be thinner and with being overweight. Further, a substantial number of schoolchildren, especially girls, reported iron and folate intakes below the estimated average requirements but low tissue stores of iron (7% of boys and 8% of girls at baseline; 3% of boys and 15% of girls at follow up) and folate

(0% of boys and 1% of girls at baseline; nobody at follow up) did not relate to the reported low intakes. Social disadvantage emerged as a more important predictor than dietary factors of low iron stores among girls only and of high dental caries among all children.

CONCLUSIONS: Fear of fatness was particularly prevalent among young Irish adolescent girls and was found to be associated with systematic under-reporting of energy intakes. The prevalence of overweight has increased dramatically over the past ten years and a standard method of assessment is urgently needed for evaluation of obesity prevention initiatives among Irish schoolchildren. The discrepancy between apparently low iron and folate intakes and sufficient actual tissue stores highlights the importance of including an independent measure of reported energy validity when assessing the reported diets of adolescents. Nonetheless, those children with low iron stores are likely to have reduced concentration levels adversely affecting academic progress. They are also at risk of iron deficiency anaemia, thus representing a serious public health concern

Chapter 1

Body weight status, nutrition, and dental health of young adolescents.

1.1 Adolescence: a time of development.

Adolescence is a time of both physical and psychological change: literally it is the time between childhood and adulthood. The child, through a series of physiological changes that occur over a relatively short time but at different ages between children, develops adult features, shape and size. As they grow older children assert their independence, even in the food choices that they make. There is an increasing awareness that chronic diseases during adulthood have precedence in adolescence. Dietary patterns, body weight and physical activity track from adolescence into young adulthood (Parsons et al 1999). But it would seem that the immediate concern of the adolescent, in Western societies, is not the prevention of future disease but rather the attainment of the "ideal" body size and shape dictated by media and peer influences (Patton et al 1997). Concurrent with the rising trend of child obesity is a fear of fatness. Excess weight has already been proven to be a risk to future well-being. Now, it is emerging that inappropriate dietary practices to prevent the gain of weight threatens both physical and psychological development.

1.2 Fear of fatness

Concurrent with the increasing prevalence of obesity among children is the prevalence of fear of fatness, particularly among young adolescent girls (Flynn 1997). The feeling of being fat can be the reason for going on a diet (Nylander 1971). Obese children have been found to be significantly more likely to engage in dieting behaviours, express weight concerns, restrain their eating and exhibit more dissatisfaction with their body image than average-weight children (Vander Wal and Thelen 2000). However, research has shown that many adolescents, particularly girls, believe that they are fat and diet even though their weight-to-height ratio is normal (Rosen and Gross 1987; Richards *et al* 1990; Wardle and Marsland 1990; Ryan *et al* 1998; Neumark-Sztainer and Hannan

2000). It has been concluded that the driving force behind weight reduction for these girls must be psychological or social (Rosen and Gross 1987). Indeed, these concerns may be well-founded considering that data from the British 1958 birth cohort demonstrated that, at 23-years-old, women who had been obese at 16 years had significantly fewer years of schooling and lower earnings than their non-obese peers (Sargent and Blanchflower 1994). These relationships have not been seen in men (Parsons *et al* 1999).

Although boys and girls express similar awareness of the sociocultural preference for thinness and report similar feelings concerning their body image, girls are more personally concerned about becoming fat (Shapiro *et al* 1997). Available evidence suggests that at age 7 years and possibly earlier, children have acquired adult cultural perceptions of attractiveness (Feldman *et al* 1988). Findings concerning the stereotyping of obesity show that children attach strong negative attributes (ugly, lazy, stupid and selfish) to pictures of fatter children (Wardle *et al* 1995).

1.2.1 Assessing fear of fatness and weight control practices.

Body image concerns among children are mainly assessed from figure preferences, video projection techniques, and/or questionnaires. Using figure drawings, children have been asked to indicate their perceived and ideal body size, as illustrated by sex-specific silhouettes that range in size from very thin to obese (Ricciardelli and McCabe 2001). Estimates of children's own body size, even as young as 6 years of age, have been shown to be accurate (Gardner *et al* 1997). In addition, test-retest reliability for the figure preference task for children aged as young as 8 years has been found to be high (Wood *et al* 1996).

Computerised video projection techniques based on methods developed for adolescents and adults have been used to assess body image disturbance reliably and validly in children as young as 6 years (Gardner *et al* 1997). Children are asked to adjust the width of a distorted image of their body, which is projected on the video screen, until it matches their perceived or ideal body size (Ricciardelli and McCabe 2001). However, video projection has rarely been used with children due to the fact that the experimental procedure is time consuming (Gardner *et al* 1997).

Questionnaires used to assess body image concerns among young children include the Body Dissatisfaction Scale of the Eating Disorder Inventory (BD-EDI), revised for children (Gardner et al 1997; Wood et al 1996). This scale assesses beliefs that various parts of the body are too large or are associated with fatness. Test-retest reliability and internal consistency for BD-EDI are very high for children as young as 8 years of age (Ricciardelli and McCabe 2001). Low to moderate correlations, comparable in size to those found with adolescents and adults, have been found between the BD-EDI and body dissatisfaction as assessed by figure preferences (Wood *et al* 1996). The Body-Esteem Scale was designed to assess children's attitudes and feelings about their body and appearance. It has good internal consistency and moderate test-retest reliability with children as young as 8 years (Mendelson *et al* 1996). Correlations between the Body-Esteem scale and body dissatisfaction as assessed by figure preferences have also been found to be moderate (Mendelson *et al* 1996). Overall, psychometric data for the instruments used to assess body image concerns in children are very good and there is sufficient evidence, which indicates that they can be used reliably and validly to measure body image concerns among children (Ricciardelli and McCabe 2001).

Instruments have been developed to investigate the prevalence of disordered eating symptoms to early indicators of eating disturbance among children. Investigating eating disturbance in children poses a challenge, as the instruments need to be simple so that children can comprehend them easily, and should not be too intrusive or suggestive of alternative eating strategies, yet they need to be sensitive enough to detect problems

(Ricciardelli and McCabe 2001). The types of dieting behaviours used by respondents remains unclear; dieting behaviours may include healthy strategies, such as increasing fruit and vegetable consumption, or unhealthy methods, such as skipping meals or using diet pills (Neumark-Sztainer *et al* 2000). Often in comprehensive surveys of adolescent health, complete scales are not included owing to constraints on the number of items that may be included and the limited nature of the questions assessing dieting and disordered eating needs to be taken into account when drawing conclusions (Neumark-Sztainer *et al* 2000). An example of such a scale is the adolescent dieting scale which is comprised of nine items and measures three dieting strategies: calorie counting, reducing food quantities at meals, and skipping meals (Lewis *et al* 1988).

1.2.2 Body image concerns and weight control practices among young adolescent girls.

Research suggests that weight and eating concerns are infrequent before adolescence and become more frequent for girls as they move into adolescence (Richards *et al* 1990). By 13 years of age, research has found that a substantial proportion of girls have endorsed items stating that they were terrified of gaining weight and worried about eating when they were upset (Richards *et al* 1990). In fact, fear of fatness is so pervasive among female adolescents it has been described as a 'normative discontent' (Wadden *et al* 1989).

It has been suggested that the major increase in subcutaneous fat, during puberty, is troubling young adolescent girls and that this, and their sexual changes, may lead to self-consciousness and more negative body image, perceptions of being overweight, less satisfaction with weight, inaccuracy in perceptions of weight, and desires to be thinner (Brooks-Gunn and Warren 1985; Richards *et al* 1990). The body parts mentioned by the girls (hips, thighs, waist, and stomach) are the same parts that concern adult women reflecting the fashionable pre-pubescent shape for females (Morris *et al* 1989; Nowak *et al* 1996).

Three decades of population surveys of teenage girls in Western communities have documented that between a third and two-thirds of teenage girls are 'on a diet' at any one time (Patton *et al* 1997). A recent study of Irish 15-year-old girls found a high level of dissatisfaction with body weight where 27% of those girls expressing a desire to be lighter actually perceived themselves to be of normal- or under-weight (Ryan *et al* 1998). Reported slimming methods included 'avoiding sugary foods' (81%), 'exercising' (80%), 'skipping meals' (52%), and 'dieting' (44%; Ryan *et al* 1998). The reported prevalence of unhealthy slimming practices (self-induced vomiting and laxative use) among this Irish group was comparable to results obtained elsewhere (Killen *et al* 1986; French *et al* 1995; Ryan *et al* 1998).

1.2.3 Body image concerns and weight control practices among young adolescent boys.

Boys are more likely to try to gain weight compared to their female counterparts (Nowak *et al* 1996). Rather than a preoccupation to become thin it has been reported that boys are more likely to be concerned about being too thin (Moore 1990). An increase of dissatisfaction with body shape has been observed with increasing age and may be related to longer exposure to societal and media ideals of male body shape. Boys who report dissatisfaction with their body shape, seem most likely to desire an increased chest and arm size and decreased abdomen size indicating a wish to increase weight and muscularity, rather than to lose weight (Moore 1990). Even among overweight males who perceived, correctly, that they were overweight (*n* 155), more than three-quarters did not desire sufficient weight loss to enter the normal-weight range (Moore 1990). Boys expressing less concerns of weight and eating have been found to spend more time in sports (Richards *et al* 1990). This is probably not surprising as athletics generally provides opportunities for maintaining a desired body build and weight (Richards *et al* 1990). Weight loss is not a sufficiently important concern for boys to warrant the use of fasting, self-induced vomiting, and stimulant use as has been reported among adolescent girls (Moore 1990). In contrast to girls, where early puberty is found to have a more negative impact on their satisfaction with their bodies, late puberty seems to be most distressing for boys (Siegel *et al* 1999).

1.2.4 Environmental influences on weight concerns among young adolescents.

Weak associations between socio-economic class (SEC) and both dieting and disordered eating behaviours among girls, and an increased risk for disordered eating among boys with low SEC has been recently reported (Neumark-Sztainer and Hannan 2000). Data from the Minnesota Adolescent Health Survey found that girls with high SEC dieted more than girls with low SEC, but were less likely to report vomiting, use of laxatives, and binge eating (Story *et al* 1995).

Rather than SEC, socio-culture including the media, parents and peers, appear to influence body image among adolescents. Several cross-sectional studies have observed a positive association between exposure to beauty and fashion magazines and higher levels of weight concerns or eating disorder symptoms in girls (Stice *et al* 1994). Little is known about the sociocultural and media influences that may affect adolescent boy's body image and body change strategies (Ricciardelli and McCabe 2001). Among both girls and boys, making considerable effort to look like same-sex figures in the media was found to be predictive of developing weight concerns and becoming a constant dieter (Field *et al* 2001). Both young girls and boys attribute the beliefs that 'it is important for men and women to be thin', 'thin people are happy people', and 'fat people have very few friends', to their family, extended family, peers, and the media (Shapiro *et al* 1997).

Independent of age and BMI, parental influences have been found to be predictive of becoming highly concerned with weight and becoming a constant dieter (Field *et al* 2001). Preadolescent children who perceive that their mother is frequently trying to lose weight were found to be more likely to become highly concerned with weight (boys) or constant dieters (girls; Field *et al* 2001).

1.2.5 Adverse consequences of fear of fatness among children and young adolescents.

Medical case studies of small numbers of British and American children and young teens document retarded growth and delayed puberty secondary to self-imposed caloric restriction (Davis *et al* 1978; Pugliese *et al* 1983). Restricted energy intake among preadolescents not only can retard growth and sexual development it can also deleteriously affect learning, ability to concentrate, and school performance (Nylander 1971; Garfinkel and Garner 1982).

A recent American study has found correlations between substance use behaviour (tobacco, alcohol, and other illegal drug use) and both dieting and disordered eating (self-reported binge-purge cycling; Neumark-Sztainer and Hannan 2000). An earlier study corroborates these findings suggesting that independent of age, BMI, and known predictors of tobacco uptake, contemplation of cigarette use has been positively related to concern about weight, whereas experimentation with cigarettes was positively related to engaging in weight control behaviours (Tomeo *et al* 1999). Although these relationships were seen in both boys and girls, they seemed to be stronger among girls (Tomeo *et al* 1999). The study of the pursuit of thinness among 15-year old Dublin schoolgirls found that 19% of those who reported having tried to lose weight began or continued smoking as a slimming practice (Ryan *et al* 1998).

The most cited method for weight control, as reported by adolescents, is exercise (Rosen and Gross 1987; Ryan *et al* 1998; Tomeo *et al* 1999). Studies among non-athletic adolescents who express body image concerns have not reported whether exercise is performed to such an extent to cause adverse effects on growth and development. Training or competition has been implicated as a cause for short stature and decreased body mass of some pubertal athletes, particularly those that participate at gymnastics, dance, or wrestling (Rogol *et al* 2000).

Persistent and negative thoughts about how much is eaten and if she is exercising enough in the young adolescent girl may indicate she is suffering emotionally and socially (Richards *et al* 1990). Eight and ninth grade American girls who report concerns about their weight and eating have been found to experience more dysphoric daily moods, and poorer attention span, report more symptoms of depression and lower levels of self-perceptions, and are more socially withdrawn (Richards *et al* 1990). They also spend more time alone and less with friends and in social activities (Richards *et al* 1990).

1.2.6 Implications of an inadequate dietary intake during young adolescence.

Unhealthy eating and disordered eating behaviours among young adolescents are of concern in that they have the potential to adversely affect nutrient intake, mental health status, and long-term health outcomes (Neumark-Sztainer *et al* 1999). Boys who use food for weight reduction reduce high-fat foods, high-sugar foods, and snacks, and increase some low-fat foods (Nowak 1998). Not only do girls reduce high-fat foods, they also reduce bread, meat, and dairy products, and skip meals when dieting (Nowak 1998). Unhealthy weight control practices reported among Irish adolescent girls (15-

years-old) include the random avoidance of staple foods, fasting, smoking and purging (Ryan *et al* 1998). The lower intake of staple foods and the tendency to skip meals frequently outlast the diet (Nowak 1998). Unfortunately, in defiance of their intended goal, there may be a potential link between disordered eating and the development or exacerbation of obesity (Mellin *et al* 1992). Dieting and disordered eating behaviours may also be indicative of increased risk for the later development of eating disorders (Nylander 1971; Patton *et al* 1999).

Few studies have documented or measured the nutrient intake of adolescents who express fear of fatness or report trying to lose weight. It is well recognised, however, that to support the growth and development of adolescents a diet of high nutritional quality is required and, as such, adolescents, particularly girls, represent a nutritionally vulnerable group (Flynn 1997). Malnutrition secondary to avoidance of certain foods can lead to serious disorders such as osteopenia, anaemia, and syndromes related to deficiencies of vitamins, minerals, essential fatty acids, and trace elements (Rogol *et al* 2000). The adaptive response is marked by a decrement in basal (and resting) metabolic rate and a decrease in protein synthesis, the latter being an energy-intensive process (Rogol *et al* 2000). All may lead to a decrease in physical activity, which is an attempt to decrease ongoing energy losses (Rogol *et al* 2000).

1.2.7 Association of fear of fatness with eating disorders in young adolescents.

The rise in preoccupation with weight control in developed countries has paralleled a rise in the prevalence of eating disorders (Kendler *et al* 1991; Patton and Szmukler 1995). The occurrence of symptoms of depression and anxiety in teenage dieters, common in anorexia nervosa, prompted a suggestion that adolescent eating disorders exist on a spectrum ranging from normal teenage dieting at one end to more debilitating clinical eating disorders at the other end (Nylander 1971). Predictors of higher eating disorder scores for both sexes (6 to 14 years) have included height and weight, children's perceptions of parental concerns about their body size, low body esteem, and depression (Gardner *et al* 2000). For girls only, a larger perceived body size and smaller idealised body size were also predictors (Gardner *et al* 2000). In a multivariate analysis of intermediate and extreme dieters, psychiatric morbidity carried a clear association with extreme dieting and there was no evidence of a weight related association (Patton *et al* 1997). This finding is consistent with extreme dieting lying on a spectrum with clinical eating disorders. Differences in the incidence of eating disorders between the sexes have been accounted for by the high rates of earlier dieting and psychiatric morbidity in female subjects (Patton *et al* 1999). Patton, *et al*, (1999) found that adolescent girls who diet at a severe level (according to the adolescent dieting scale described in section 1.2.1) are 18 times more likely to develop an eating disorder than those who did not diet, and those who diet at a moderate level are 5 times more likely to develop an eating disorder.

1.3 Prevalence of obesity among adolescents.

The prevalence of childhood obesity is increasing rapidly around the world (WHO, 1998). Undernutrition remains the nutrition problem of greatest concern in developing countries, but even these countries are reporting worrisome rates of overweight among pre-school children (de Onis and Blossner 2000). Twenty-one of 38 developing countries had a prevalence of overweight greater than 5% and 16 countries with more than one time point recorded showed a rising trend (de Onis and Blossner 2000).

Approximately one in five children in the United States is overweight (Troiano *et al* 1995). Secular trends appear to be accelerating, with larger increases in the prevalence of overweight seen during the latter part (1983 through 1994) of the Bogalusa Heart Study than during 1973 through 1983. Similarly, increases in body weight were observed between NHANES II (1976-80) and NHANES III (1988-94; Freedman *et al* 1997, Kuczmarski *et al* 2000). The prevalence of overweight among 10-12 year old children in Montreal, Canada was 15.9% in 1993 and was found to increase by 1.0% per year (O'Loughlin *et al* 2000). European data concerning the occurrence of obesity in young subjects (15-24 years old) revealed a regional influence, the values ranging between 5.2% in Austria and 1% in Italy (Martinez *et al* 1999). A marked increase in the weight for height index was demonstrated in English and Scottish boys and girls aged 9-10 years old, which was mainly due to increases in fatness, confirmed by consistent increases in triceps skinfold thickness (Hughes *et al* 1997). In an Irish study, conducted in 1990, 1.1% of boys and 2.6% of girls (12-15 years) had a body mass index (BMI) of greater than 26 kg/m^2 indicating a risk of overweight (Hurson *et al* 1997).

1.3.1 Body fat distribution during adolescence.

Obesity is the result of excessive adipose tissue (Daniels *et al* 1997). Women have more fat and less lean tissue than men and they typically store more fat in the hips and thighs (gynoid distribution) and less centrally in the trunk (android distribution; Ley *et al* 1992). Fat patterning is now seen as one of the major contributors to coronary heart disease and diabetes (Fox *et al* 2000). Recent studies in children show that a greater distribution of central fat is correlated with less favourable patterns of serum lipoprotein concentrations and blood pressure (Daniels *et al* 1999). Because adiposity and cardiovascular risk factors track moderately from childhood to adulthood, identification of children with high central adiposity is important (Wattigney *et al* 1995; see section 1.3.7).

The use of imaging techniques to quantify central adiposity is limited due to factors such as cost, availability and, in the case of computed tomography, radiation exposure (Goran *et al* 1998*a*). Triceps skinfold may be used to indicate percentage body fat and subscapular skinfold to indicate total body fat but the measurement technique for skinfolds can be problematic, and inter- and intra-reliability are known to decrease with increasing skinfolds (Kuczmarski, 1993). Height, weight, and the lack of these or other measures to corroborate the skinfold data also tend to mute the use and interpretation of skinfolds to measure trends in obesity (Kuczmarski, 1993). The waist-to-hip ratio is used among adults where a high ratio indicates central obesity that correlates to intra-abdominal adipose tissue but this correlation is poor among children probably because waist and hip measurements are highly age dependent (Goran *et al* 1998*a*; Power *et al* 1997). The measurement of waist circumference alone has been shown to be a superior indicator of regional fat distribution among a large sample (*n* 580) of boys and girls aged 3-19 years (Taylor *et al* 2000). Recent information suggests that waist circumference is also a promising index to predict overweight at puberty from childhood (Maffeis *et al* 2001).

1.3.2 Identification of the overweight child and young adolescent.

There are various measures recommended in the literature to identify overweight or obese adolescents but these are neither standardised nor used in research or practice uniformly. Measurements of skinfold thicknesses and body circumferences that assess body fatness are discussed above (chapter 1.3.1). The accurate measurement of total body mass requires sophisticated and often expensive methods that have limited applicability in the clinical setting (Daniels *et al* 1997). Excess body mass can be measured directly by using weight and height. Many clinicians and investigators have used measures of body weight standardised for height as an approximation to measurement of adipose tissue mass (Daniels *et al* 1997). But differences in the timing of weight and height growth differ from child to child during adolescence which complicates the accuracy of definitions of overweight (Bini *et al* 2000). Thus, the gender and the level of sexual maturation of an adolescent has been reported as having a stronger correlation to percentage fat than age (Daniels *et al* 1997; Bini *et al* 1997).

Actual relative weight assesses overweight relative to a target weight at the weight-for-age percentile that corresponds to the youths observed height-for-age percentile taken from local reference data (Himes and Dietz 1994). This approach, however, incorrectly assumes that the distribution of weight within an age group is identical to that of weight within a corresponding height group. Because stature and weight are highly correlated within age groups, the distribution and resultant percentiles of weight-for-stature are more narrow than those of weight-for-age (Himes and Dietz 1994). Actual relative weight is further limited in that it does not correlate as strongly as body mass index with percentage adiposity (although it is age specific) and comparisons between studies are difficult as the choice of reference data varies (Roche 1983).

The body mass index (weight/height^2; BMI) is widely used in adult populations where a cut-off point of 30 kg/m^2 is recognised internationally as a definition of adult obesity (WHO 1995). However, among children, boys and girls differ substantially in body fatness given a similar BMI, with the girls having greater total body fat than boys at the same level of BMI from 7 to 17 years (Daniels *et al* 1997). In individuals with equivalent percent body fat, those with more central obesity have been found to have a lower BMI compared with those with more peripheral obesity (Daniels *et al* 1997). Therefore, anthropometric cut-offs for fatness need to be adjusted for age and, in adolescence, for maturation as well (Power *et al* 1997). However, definition of childhood obesity, based on the BMI, is associated with high specificity, and so will identify few non-obese children as obese if used clinically as a screening tool (Reilly *et al* 2000).

There are currently three recognised methods of defining body weight in children based on BMI values. The first method derived age-specific cut-off values that correspond to the 85th and 95th percentiles of BMI to define the risk of overweight and overweight, respectively, from a single data set of the US adolescent population (Himes and Dietz 1994; Must *et al* 1991*a*; Must *et al* 1991*b*). This method has been superseded by BMI-for-age charts derived by the Centre for Disease Control (see appendix A.5; Kuczmarski *et al* 2000). The BMI-for-age charts for boys and girls include a 85th percentile and a 95th percentile to identify risk of overweight and overweight respectively (Kuczmarski *et al* 2000). The advantage of these charts is that they were developed with U.S. national survey data (1963-94) excluding data from the 1988-94 National Health and Nutrition Examination Survey III (NHANES III) for children older than 6 years (Kuczmarski *et al* 2000). The NHANES III weight and BMI data for ages $\geq$ 6 years was not included (based on the conclusions of a variety of experts including paediatricians, epidemiologists, public health nutritionists and statisticians) in order to circumvent the influence of increases in body weight that occurred between NHANES II and NHANES III (Kuczmarski *et al* 2000). Without this exclusion, overweight would be under-classified in children and adolescents (Kuczmarski *et al* 2000). The third method includes the use of proposed age and sex-specific cut off points from 2-18 years that pass through the widely used cut-off points of 25 and 30 kg/m^2 for adult overweight and obesity at age 18 (Cole *et al* 2000). The cut-off points based on a heterogeneous worldwide population can be applied widely to determine whether the children and adolescents they identify are at increased risk of morbidity related to obesity (Cole *et al* 2000). However, Reilly et al 2000 have found a substantial underestimation of obesity prevalence, more marked in boys than girls, which could lead to artefactual differences in obesity prevalence (based on these cut-offs) between the sexes.

1.3.3 The role of genetics and socio-economic background on childhood overweight and obesity.

A comprehensive review of longitudinal studies addressing the phenotypic inheritance of fatness observed that offspring fatness increased with parental fatness, at all ages, from childhood into adulthood (Parsons *et al* 1999). However, the strong relationship between parental and offspring fatness is likely to represent both genetic factors and cumulative environmental influences including learnt lifestyle behaviours (Parsons *et al* 1999). It is suggested that the child of an obese parent is at increased risk of becoming fat early in life, and once relatively fat, he/she is more likely to be so later in adulthood (Lake et al 1997). This phenomenon cannot be explained solely by genetics as most obesities must be caused by environmental and lifestyle factors in modern life, since the large increases in prevalence of obesity are occurring within a relatively constant gene pool (Prentice 1997).

Associations between low SEC and greater fatness in studies of adults have been attributed to two main causal models: low SEC may promote the development of fatness or, alternatively, greater fatness may lead to downward social mobility and thereby lower SEC (Parsons *et al* 1999). Longitudinal studies have identified that both in males and females, there is a remarkably consistent negative relationship between SEC in childhood and fatness in adulthood (Parsons *et al* 1999). This negative relationship is not quite so consistent when fatness is measured in childhood, or cross-sectionally (Parsons *et al* 1999). Being born into a particular social class cannot in itself 'cause' obesity, but characteristics of socio-economic groups related to material circumstances and behaviour or knowledge, which ultimately influence energy balance, might (Parsons *et al* 1999).

1.3.4 Maturation with respect to the aetiology of childhood overweight and obesity.

The extent to which changes in adiposity during childhood and adolescence, that relate to normal physiological development, correspond to changes in excess fat is not clear (Power *et al* 1997). Observations suggest that critical periods exist for the development of obesity and its complications during childhood and adolescence (Dietz 1994).

BMI increases in the first year of life and subsequently decreases (Rolland-Cachera *et al* 1884; Rolland-Cachera *et al* 1987). Beginning at approximately 5 years of age, BMI again begins to increase and this has been called the period of adiposity rebound (Rolland-Cachera *et al* 1984; Rolland-Cachera *et al* 1987). Longitudinal studies suggest that the timing of adiposity rebound may have a significant effect on fatness in adolescence and adulthood, where BMI and subscapular thickness were significantly greater among children whose adiposity rebound began early compared to those whose adiposity rebound was average or late (Rolland-Cachera *et al* 1984; Rolland-Cachera *et al* 1987; Siervogel *et al* 1991; van Lenthe *et al* 1996). The effect of adiposity rebound on eventual adiposity may be that children who rebound earlier grow fatter for a longer period of time (Dietz 1994).

There is also evidence that a relationship between greater prepubertal fatness and early maturation (especially among girls) seems to account for the observed relationship between early maturation and greater fatness in adulthood (Rolland-Cachera *et al* 1987; Frisch 1989; Stark *et al* 1989; Power *et al* 1997; Falorni *et al* 1997; Parsons *et al* 1999). It is not clear what mechanisms underlie the association between advanced biological maturity status and fatness, or between delayed maturity status and leanness; possibilities include the contrast between internal and subcutaneous fatness (Buenen *et al* 1994). A recent longitudinal study reported findings that indicated the adiposity rebound is an important period for girls, in regard to the development of subsequent overweight and increased levels of adiposity in adulthood (Guo *et al* 2000). The pubescence period is important for both sexes in that the rate of increase in BMI and the BMI value at the maximum increase are related to high adult BMI levels, but more so in men than in women (Guo *et al* 2000). The maximum BMI attained at post-pubescence is strongly related to the degree of fatness in adulthood, more so for women than for men (Guo *et al* 2000). The relationship of these BMI parameters with corresponding adult levels of overweight were found to be stronger than the relationship or the effects of birth weight and adult levels of physical activity and alcohol and cigarette use on adult levels of overweight (Guo *et al* 2000).

1.3.5 Energy intake in the aetiology of childhood overweight and obesity.

Weight gain is ultimately the result of an imbalance between energy intake and total energy expenditure. It is not clear whether obesity develops because of an excess energy intake relative to total energy expenditure, a reduced total energy expenditure relative to energy intake or a combination of both (Livingstone 2000). There is increasing discussion on the importance of dietary factors other than total energy intake, including dietary composition (particularly percentage energy from fat) and the energy density of the diet, with the development of overweight (Parsons *et al* 1999). A review of the extensive data on energy intakes of children in Europe could not draw definite conclusions about the contribution of food intake to the increasing prevalence of overweight and obesity (Livingstone 2000). Despite the biological plausibility that higher energy intakes lead to increased energy storage and body fat, many dietary surveys in Western countries have observed inverse relationships between energy intake and BMI (Parsons *et al* 1999). However, validation studies using doubly labelled water estimates of energy expenditure to assess the accuracy of energy intake reporting in children, indicate that energy intake data are prone to bias and thus, undermine these findings (Bandini *et al* 1990; Livingstone *et al* 1992). This is discussed in more detail below.

Limited data suggest that the percentage of total fat energy, independent of total energy intake and activity level, may contribute to obesity in children (Gazzangia and Burns 1993; Maffeis *et al* 1996). Children at high risk of obesity, based on parental obesity status, had similar total energy intakes but a higher percentage of fat energy and a lower percentage of carbohydrate energy than children at low risk of obesity (Eck *et al* 1992). Lack of knowledge about offspring's eating habits, acceptance of sweet consumption, and provision of much money for buying sweets have also been observed to precede an increased risk of overweight a decade later in young adulthood (Lissau *et al* 1993).

1.3.6 The role of physical and sedentary activities in the aetiology of childhood overweight and obesity.

Available evidence suggests that the trends in obesity rates are related more to time spent at sedentary activities and a reduction in energy expenditure than to an increase in caloric intake (Seidell, 2000; Berkey, *et al*, 2000; Janz, *et al*, 2000; Stafford and Wells 1998). Cross-sectional data from the UK and longitudinal data from the Netherlands show that during adolescence the time spent by children on exercise decreases considerably (Kemper et al 1999; Armstrong et al 1990). Longitudinal studies in children have shown that the impact of individual differences in energy expenditure on future changes in weight and body composition differ according to stage of growth and development (Goran *et al* 1998*b*). A reduction in energy expenditure among prepubertal girls, that occurred despite a continued gain in fat and fat free mass which would be expected to contribute to an increased energy expenditure, was not associated with a concomitant reduction in energy intake (Goran *et al* 1998*b*). These results suggest the possible existence of an energy-conserving mechanism, through reduced physical activity, before puberty in girls (Goran *et al* 1998*b*). Because boys generally mature later than girls, it is possible that they also may reduce physical activity at later ages closer to puberty (Goran *et al* 1998*b*). Intervention studies suggest that, whatever its role in the genesis of obesity, increases in activity are an important component of programmes designed to treat obesity and maintain weight (Parsons *et al* 1999).

TV watching has been observed as more closely related to increased skinfold thickness and BMI than vigorous activity among a US national representative sample of 4063 children aged 8-16 years (Andersen *et al* 1998). Furthermore, children that watch more TV (four or more hours per day) are less likely to participate in vigorous activity and tend to have the higher BMI (Andersen *et al* 1998). An ongoing study of >10,000 boys and girls from all over the US showed that boys and girls who spent more time viewing television (TV) and playing video/computer games during a year had larger increases in BMI (Berkey *et al* 2000). A review of European and North American studies, examining tracking of vigorous activity during late childhood and adolescence, observed that inactivity appears to track better than activity (Malina 1996). The role of inactivity in obesity may be even beyond the fewer calories expended; television advertising tends to push foods that are energy-dense and nutrient poor (Birch and Fisher 1998). It has been shown that children request foods that are more frequently advertised on TV, and TV viewing is correlated with caloric intake (Taras *et al* 1989). Sedentary activities that are regularly associated with eating also can become conditioned cues for eating, such that a child who is not hungry and begins TV watching may find that the TV cues eating (Epstein *et al* 1996).

The importance of a physically active lifestyle for reducing the risk of morbidity and mortality is well documented with benefits including a reduction of low density lipoproteins while increasing high density lipoprotein; improvement of glucose metabolism in patients with type II diabetes; improved strength, self esteem and body image; and reduction in the occurrence of back injuries (Pate *et al* 1995; Sothern *et al* 1999). In fact, sedentary lifestyle is considered a risk factor for coronary artery disease (Fletcher *et al* 1996). It has been suggested that young girls should participate in resistance or strength exercise along with other physical activities to prevent osteoporosis in later life (Loucks 1988). Available guidelines recommend that adults and children older than two years accumulate 30 minutes of at least moderate-intensity physical activity on most but preferably all days of the week (Pate *et al* 1995).

1.3.7 Long-term health implications of child and adolescent fatness.

Obesity and overweight in adulthood are associated with increased mortality, coronary heart disease, hypertension, dyslipidaemia, diabetes mellitus, gallbladder disease, osteoarthritis, and some cancers (Pi-Sunyer 1991). Longitudinal studies among British children have reported that fat children are at high risk of being fat adults: the fattest 2% of adolescents at ages 11 years and 16 years have a high risk of obesity in adulthood (Power *et al* 1997*b*). Risks for children identified at age 7 years are weaker, but are also elevated (Power *et al* 1997*b*). Despite such findings, only a small proportion of obese adults were fat as children (Parsons *et al* 1999). It may be the timing of the onset of childhood obesity at critical periods that is associated with the promotion of adult obesity (discussed in section 1.3.4). Nonetheless, it has been suggested that long-term morbidity and mortality during adulthood result from adolescent obesity directly, rather than from the effects of adolescent obesity on adult weight (Must *et al* 1992).

Adolescent overweight is associated with increased adult morbidity in men for gout, and in women for arthritis, and reported functional limitations, as indicated by the ability to perform activities of daily living (Must *et al* 1992; Power *et al* 1997). Among women, childhood overweight may be associated with menstrual problems in early adulthood (Lake *et al* 1997*b*). Adolescent overweight is positively associated with increased mortality, especially for coronary heart disease, atherosclerosis and colorectal cancer among both men and women, but primarily in men (Must *et al* 1992; Power *et al* 1997). Associations between obesity and important risk factors for cardiovascular disease and mortality, such as hypertension, hyperlipidaemia, and hyperglycaemia, have been shown in cross-sectional studies in children (Berenson 1980). Hyerinsulinaemia has been found to be related to the amount of intra-abdominal fat among obese children (Bonadonna *et al* 1990; LeStunff and Bougneres 1994). In addition, cardiovascular risk factors have been related to the amount of intra-abdominal fat, as measured by MRI, of obese adolescent girls (Caprio *et al* 1996). In obese children and adolescents numerous studies report associations between central adiposity, as measured by skinfolds, and disturbances in lipid and lipoprotein concentrations, particularly triacylglycerol and HDL-cholesterol concentrations (Freedman *et al* 1989; Kikuchi *et al* 1992; Zwiauez *et al* 1992).

1.4 Age-related methodological considerations involved in dietary assessments of children and adolescents.

The accurate assessment of food intake in children and adolescents is of concern as dietary habits formed early in life in response to both physiological requirements and psycho-social pressures may have a considerable impact on long-term health status (Livingstone and Robson 2000). Dietary surveys, based on children's recall of food intake, are subject to a variety of errors, including under-reporting and over-reporting (Crawford *et al* 1994; Domel *et al* 1994), and incorrect identification of foods because of a lower level of knowledge of foods and their preparation (Emmons and Hayes 1973). In the few studies that have attempted to describe portion sizes, the results have been somewhat inconclusive and contradictory and, therefore, it cannot be assumed that inclusion of any quantification tool (for example, food models, food atlas, etc.) will assist children to estimate portion sizes (Livingstone and Robson 2000).

Independent of direct weighing or household measures as quantification tools, adolescents under-report dietary records (weighed or estimated) and, thus, underestimate energy intake (Bandini *et al* 1990; Livingstone *et al* 1992). The diet history methodology apparently overcomes the age-related bias which is present in reporting diet records, but it lacks precision at the individual level with 35% of the results by diet history outside the 95% confidence interval that assumes a valid measure of habitual intake (Livingstone *et al* 1992). The adolescent diet is characterised by missed meals, unconventional meals, fast food, and frequent 'snacking' (Rolls 1988). The variability in nutrient intake is lowest for the nutrients that are eaten regularly in the diet and highest for the nutrients that are eaten in large amounts only occasionally, e.g. copper, carotene, retinol, vitamin B_{12}, vitamin E, polyunsaturated fatty acids and cholesterol (Livingstone and Robson 2000). Given the extent of variability, in food intake that has been observed in adolescents, multiple 24h recalls would be required to estimate food intake at the individual level but, these are also susceptible to the inherent problems of estimation of portion size, social-desirability responding and retrieval of information from memory (Miller *et al* 1991). With respect to food frequency questionnaires little attention has focused on deciding which foods should be included for adolescent age-groups (Livingstone and Robson 2000).

1.4.1 The phenomenon of under-reporting energy intake among young adolescents

The assessment of dietary intake is known to be compromised by frequent and consistent under-reporting associated with obesity, dieting and weight consciousness (Livingstone and Robson 2000). Self-reported dietary intakes, particularly from overweight adolescents, are likely to be biased, mainly in the direction of under-reporting (Livingstone *et al* 1992; Bandini *et al* 1990). Up to 40% of energy intake in obese adolescents may go unreported and is found to be age-related with the higher percentage of under-reporting found among the older adolescents (Bandini *et al* 1990; Livingstone and Robson 2000; Fisher *et al* 2000). Males are just as likely as females to under-report (Livingstone *et al* 1992). In adolescence the additional demands on recording imposed by increased energy requirements, unstructured eating patterns and a significant degree of out-of-home eating may be potent factors leading to loss of motivation, forgetfulness and ultimately reporting accuracy (Livingstone and Robson 2000). Furthermore, these factors may be compounded by an exaggerated concern about body shape and image resulting in conscious or subconscious inhibition of eating (Livingstone and Robson 2000).

Energy intake in adult populations can be evaluated by comparison with presumed energy requirements and expressed as physical activity levels (Black *et al* 1991; Goldberg *et al* 1991). Estimates of energy requirements (expressed as physical activity levels) for light, moderate and heavy physical activity of 1-18 year-olds are also available which are age- and sex-specific (Torun *et al* 1996). It is important to note that validation against indices of energy expenditure identifies only the bias in the reporting of energy intake (Livingstone and Robson 2000). Therefore, whether the diet is under-reported as a whole, or whether there is a selective under-reporting of different foods leading to further bias in the reporting of nutrient intake, is not known (Livingstone and Robson 2000). Since high levels of dietary restraint, whether real or apparent, are more than likely to constitute a source of bias in dietary surveys, it is important, where possible, to characterise subgroups most likely to mis-report their food intake (Livingstone and Robson 2000).

The identification of the presence and magnitude of over-reporting of the energy intake of young children and adolescents is virtually impossible but cannot be ruled out

(Livingstone and Robson 2000). Over-reporting will remain elusive until much more experimentally-derived data on total energy expenditure are available to calculate the upper confidence interval (Livingstone and Robson 2000).

1.4.2 Recommendations for energy intake during young adolescence.

The lack of definitive quantification of nutrient needs during adolescence limits the estimation of the adequacy of observed dietary intakes among this group. The data on dietary needs of young adolescents for energy and proteins are mainly extrapolated from subjects in other age-classes (Giovanni *et al* 2000). Energy needs are defined as the dietary intake necessary to balance the energy employed for metabolism, physical activity, growth and repair of tissues and current recommendations are generally based on estimates on energy expenditure (Giovanni *et al* 2000). Anabolic activity is intense during puberty since, besides the appreciable increases in weight and height, there is an increase in the lean body mass, changes in the amount and distribution of fatty tissue and development of internal organs and systems (Gong and Heald 1994). Males gain more lean mass, which has a higher metabolic activity than adipose tissue, while females deposit more fatty mass (Giovanni *et al* 2000). Peak calorie requirements in girls occur during early adolescence (11-14 years), reflecting an earlier age of puberty, whereas peak calorie requirements for boys occur during middle adolescence (15-18 years; Wahl 1999).

Protein needs during adolescence are dictated not only by the maintenance processes but also by the growth of new tissues (Giovanni *et al* 2000). Indeed, protein requirements are the greatest during periods of active growth (Wahl 1999). Data on either of these determinants of protein requirements are lacking in adolescents and have been interpolated from studies on infants and adults (Giovanni *et al* 2000). Protein synthesis is an energy-expensive process and caloric intake must be adequate as the energy:protein ratio represents a rate limiting step for the optimal anabolism of nitrogenous sources during growth (Giovanni *et al* 2000).

Post-mortem examinations in young adults, aged 15-19 years (primarily traumatic deaths), document fatty streaks occupying about 25% of the aortic intima in both the thoracic and abdominal aorta (Wissler 1991). Lipid and lipoprotein profiles, have been shown to track from childhood to adulthood as measured by both correlation coefficients and persistence at extreme quartiles (Webber *et al* 1991). Findings from the literature indicate that the long-term prevention of coronary heart disease should begin in childhood with the control of risk factors in order to limit the extent of juvenile fatty streaks and, more critically, prevent or delay their progression to raised lesions in the years immediately after adolescence (Rolland-Cachera *et al* 2000).

The requirements for dietary carbohydrates are derived by subtracting the energy equivalents of proteins and fats from the recommended daily caloric intake (Giovanni *et al* 2000). There is no agreement on the ideal recommended intakes of dietary non-starch polysaccharides during childhood and adolescence, while for the adult population the value of 12-24g per day from a variety of foods whose constituents contain it as a naturally integrated component is generally indicated (Department of Health 1991). It is not yet known whether an ideal proportion of 'soluble' and 'insoluble' fibre should be recommended and to what extent this recommendation should be directed towards healthy subjects and/or adolescents affected by dysmetabolic conditions (Giovanni *et al* 2000).

1.4.3 Snacking: the trademark of being adolescent!.

Nutrition education has to operate against a changing background of autonomy over food choices and food ideologies as children grow up (Thomas 1991). Although concern about appearance starts much earlier, it is often not until adolescence that children have the freedom to choose foods to the degree that will substantially affect their body shape and size (Thomas 1991). If one is concerned about moderating fat intake it is important to know whether the highest proportion of fat intake is coming from foods eaten at mealtimes, which are still largely under the control of parents, or from 'youth foods' eaten in a different context (Thomas 1991). For example, a lower consumption of saturated and trans fat, and fried foods was observed among 9 - to 12 - year old children who frequently ate dinner with their family (Gillman *et al* 2000).

More than 90% of US adolescents report eating snacks between meals, usually processed "junk food" and high-fat "fast-food" items that can supply as much as one-third of the total daily nutrient intake (Munoz *et al* 1997). A study looking at socioeconomic differences in fat and sugar consumption among Finnish adolescents found socioeconomic variables to be strongly linked with the foods that adolescents ate at home, whereas those foods bought outside the home were independent of family background, showing a distinction in adolescents use of foods (Prattala 1988).

Snacks appear to contribute substantial amounts of energy and sugars to the daily diet of adolescents and contrary to popular opinion, important amounts of other nutrients (Robson *et al* 1991). It is often assumed that obese adolescents eat more "junk food" than non-obese adolescents do. However, it has been reported that both non-obese (*n* 22) and obese (*n* 21) consume a substantial portion of estimated calories (from a 14 day food record) from high-calorie, low-nutrient-dense foods (chocolate and non-chocolate confectionery, crisps, soda, ice cream, and baked goods) and that obese adolescents do not consume more calories from these foods than non-obese adolescents even when adjusted for under-reporting. These foods contributed 20-27% of the daily energy intake (Bandini *et al* 1999).

1.5 Micronutrients for health and growth in young adolescents

The micronutrients are a group of dietary constituents characterised by the low amounts in which they are found in the diet, but which nevertheless are the key to optimal macronutrient metabolism, and by the interdependent role of many of them in metabolism and physiological functions (Olmedilla and Granado 2000). Micronutrients are therefore essential for growth and development and the maintenance of adequate defences against diseases, both acquired and infectious (WHO 1996). Classical studies have shown calcium, iron and zinc to be essential micronutrients for growth and sexual maturity, and their retention by the body increases significantly during the growth spurt (Olmedilla and Granado 2000). Micronutrient deficiency may explain, in good part, why the quarter of the US population that eats the fewest fruits and vegetables (five portions a day is advised) has about double the cancer rate for most types of cancer when compared to the quarter with the highest intake (Ames 1999). Major barriers to eating more fruits, vegetables and dairy products and eating fewer high-fat foods among adolescents include a lack of sense of urgency about personal health (Neumark-Sztainer *et al* 1999). Fear of fatness is associated, particularly in girls, with unhealthy weight loss practices and have been related to significantly lower intakes of all micronutrients compared to girls who are not losing weight (Crawley and Shergill-Bonner 1995).

Assessment of adolescent's micronutrient intake from dietary records has inherent problems. Food Composition Tables present widely varying micronutrient contents due to the characteristic variations in concentrations and/or use of differing analytical procedures. Moreover, a large number of micronutrients are used as food additives or to fortify and enrich foods, and the amounts ingested in this manner are not usually included in the estimates of intake (Olmedilla and Granado 2000).

Bioavailability is the response of the individual to the diet and reflects an integration of the various components of the processes whereby an ingested nutrient becomes absorbed and utilised for a metabolic function. The determinants of bioavailability can be classified as intrinsic factors (i.e. physiological status, body stores, homeostatic control, sex) and extrinsic or dietary factors (i.e. amount ingested, the chemical form of the compound in the intestine and, the interactions of inhibitors or enhancers in the diet; Olmedilla and Granado 2000). The quantification of micronutrients from reported dietary intakes are therefore crude estimates as they do not take bioavailability into account and cannot do so accompanying knowledge of dietary inhibitors and enhancers in the same meal and of the kinetics and turnover of nutrients post-absorption (Olmedilla and Granado 2000).

1.5.1 Vitamin and mineral supplementation and fortification.

In virtually all studies of the adequacy of diet there is a minority whose intake of micronutrients is below that considered optimal (Benton 1992). There are several double-blind placebo controlled clinical trials that have reported an improvement in children's non-verbal ability (a measure of potential and a reflection of basic biological functioning) following vitamin-mineral supplementation (Benton and Cook 1991; Schoenthaler *et al* 1991; Benton 1992). It has been hypothesised that taking vitamin-mineral supplements increases the time that children spend concentrating (Benton and Cook 1991). Schoenthaler *et al* (1991) found increases in non-verbal intelligence only in those children whose levels of blood micronutrients increased following supplementation. Thus, rather than saying that vitamins increase intelligence a more accurate statement would be that a poor diet may be associated with poor performance on non-verbal intelligence tests (Benton 1992).

Adolescents in the US who reported taking supplements (*n* 143), even on an infrequent basis, were found to consume a diet that was more nutrient-dense compared to adolescents that did not report taking supplements (*n* 280). The supplement users consumed all micronutrients, except zinc, in greater quantity when compared to non-users. Only intakes of vitamin E varied significantly between daily (*n* 66) and less-frequent users (*n* 77; Stang *et al* 2000).

Enrichment refers to the addition of nutrients lost during processing (e.g., adding B vitamins and iron to refined flour) and fortification refers to addition of nutrients at levels beyond those naturally present in the foodstuff (e.g., adding vitamin C to breakfast cereals; Berner *et al* 2001). Fortification was found, in a US study, to have substantially increased the intakes of all nutrients examined except calcium, in all age/gender groups but especially in children (Berner *et al* 2001). The breakfast cereal category was found to be responsible for nearly all the intake of nutrients from fortified foods, except vitamin C for which juice-type beverages made as great or greater a contribution (McNulty *et al* 1996; Berner *et al* 2001). It has been reported that Irish schoolchildren who do not consume fortified breakfast cereals had inadequate intakes of several B vitamins and iron, but cereal consumers had intakes in line with recommended daily intakes (McNulty *et al* 1996). Several research groups have shown that vitamin and mineral supplement use is more prevalent among people with higher education levels, higher incomes and even better diet, suggesting that supplement use may not be as effective a strategy as fortification can be for reaching people in need (Berner *et al* 1996).

1.5.2 Micronutrient deficiencies of young European adolescents.

The Irish National Nutrition Survey 1990 reported that consumption of vitamins and minerals was equal to or greater than recommended levels (based on the Irish recommendations at that time which in turn were based on US recommendations; National Research Council 1980) with the exception of iron and calcium where 75% of women aged between 12-60 (*n* 511) had below the recommended intake of iron

(14mg/d) and women in the 15-25 year age group (*n* 164) also had low calcium intakes (less than 1200mg/d; Cunningham and Lee 1990; National Research Council 1980). A more recent study of a representative sample of Cork adolescents, aged 15-17 years (n 125) found that the mean intake for both calcium and iron was significantly higher for males than females (1097 mg vs. 693 mg calcium and 16mg vs. 10.3 mg of iron, in boys and girls respectively; McElligott-Tangey and Morrissey 2001). This mirrors the results of European studies that measured micronutrient intake; although the intake of micronutrients appears adequate, as compared to recommendations, calcium and iron input is low in varying proportions of males and females (Rolland-Cachera *et al* 2000). Nutritional surveys have shown that the highest prevalence of nutritional deficiencies occurs during adolescence, with specific deficiencies of calcium, iron, riboflavin, thiamin, and vitamins A and C most commonly noted (Wahl 1999).

1.5.3 Micronutrients of specific interest during adolescence.

Approximately 40% of the total adult skeletal mass is laid down during adolescence and most of the skeletal growth takes place during pubescence (Olmedilla and Granado 2000). Maximising peak bone mass within an individual's genetic potential requires optimal calcium intakes throughout growth, but especially during adolescence when the rate of calcium accretion is highest (Weaver 2000). The gap between current calcium intakes and requirements is largest among groups of adolescent females (Weaver 2000; Ryan *et al* 1997; Hurson and Corish 1997). Calcium sources include dairy products, tofu, enriched soya milk, sardines, dark-green leafy vegetables, and calcium-enriched orange juice (Wahl 1999). A study of Dublin 15-year old schoolgirls found that 95% of those girls identified as dieting (*n* 7) had calcium intakes below the lowest recommended nutrient intake compared to 20% of the total group (*n* 16; Ryan *et al* 1997). Moreover, the 'dieters' were less aware of how to achieve their calcium requirements in food terms (Ryan *et al* 1997). It was concluded that a lack of knowledge about calcium requirements and the general perception of milk as a fattening food may have contributed to low calcium intakes (Ryan *et al* 1997).

An adequate supply of vitamin D is essential for normal bone homeostasis and an insufficient intake may put growing children at risk of not reaching the peak bone mass allowed by their genetic background (Docio *et al* 1998). Natural dietary sources are limited but sufficient vitamin D can usually be provided by cutaneous synthesis under the influence of sunlight and by dietary supplementation (Lehtonen-Veroma *et al* 1999). Children with low 25(OH)D levels, the most abundant vitamin D metabolite in serum, also had lower levels of $1,25(OH)_2D$, the most potent vitamin D metabolite, which may impair their ability to actively absorb dietary calcium. In the cases of low calcium intake the vitamin D-dependent active transport is the major route for calcium absorption (Docio *et al* 1998; Lips 1996). Thus, a reduced supply of both vitamin D and calcium, common in individuals who do not consume adequate amounts of dairy products, may have particularly deleterious effect on bone tissue accumulation (Docio *et al* 1998).

Zinc needs are highest at times of maximal protein synthesis and deficiency results in metabolic disturbances of a wide range of hormones, cytokines and enzymes. In zinc depleted children (moderate-to-severe), growth, appetite, skeletal maturation and gonad development are all impaired but can be reversed with zinc treatment (Clausen and Dorup 1998). Vitamin A is an essential micronutrient for the normal function of the visual system, for growth, development, and maintenance of epithelial cellular integrity as well as for immune function and reproduction (Bhan and Bhandari 1998; WHO, UNICEF & IVACG 1997). Vitamin A deficiency also increases the liver storage of iron and this sequestered iron is subsequently rendered unavailable for incorporation into haemoglobin. It is suggested that vitamin A deficiency affects the level of infection triggering an acute-phase response that decreases plasma concentrations of transferrin and thus iron status (Northrop-Clewes *et al* 1996). However, such deficiencies are more likely to occur in developing countries and minority groups in developed countries.

1.5.4 Principal causes of nutritional anaemia in young adolescence.

Iron and folate are commonly cited as being consumed in such low amounts as to lead to increased risk of nutritional anaemia (Nelson *et al* 1993; Doyle et al 1994; McNulty *et al* 1996). The prevalence of iron deficiency and iron deficiency anaemia is surprisingly high in developed countries among apparently healthy children and young adolescents. Serum ferritin measurements are an indication of long-term iron stores which are said to be depleted when concentrations are less than 10µg/l (Dallman and Siimes 1979). Forty percent (30 boys and 51 girls) of schoolchildren, with a mean age of 15.9 years were found to be iron deleted in north-west Ireland just over ten years ago (Armstrong 1989). Among London schoolchildren (*n* 197, aged 12-14 years), 3.5% of boys and 10.5% of girls were found to be anaemic while 1% of boys and 4% of girls had low iron stores (Nelson *et al* 1993). The reported iron intake (9.6mg/d) among vegetarians from a group of Irish schoolgirls, (*n* 201) aged 15 years, was well below the estimated average requirement of 11.4mg/d (Ryan et al 1996; Department of Health 1991). In Britain, anaemia was reported to be three times more common in vegetarians than omnivores (25% *vs.* 9%) and in girls who had tried to lose weight in the last year compared with those who had not (23% *vs.* 7%; Nelson *et al* 1993).

The mean daily intakes of iron in a study of London schoolchildren, aged 12-13 years, were 10.9 mg/d and 9.68 mg/d in boys (*n* 35) and girls (*n* 30) respectively (Doyle *et al* 1994). Twenty-three percent of these London schoolgirls had an iron intake less than the lower reference nutrient intake and, based on serum ferritin concentrations, 28% of the girls and 8% of the boys had low iron stores (Doyle *et al* 1994). A high proportion of girls (64%) and boys (33%) were at the lower end of the serum ferritin range (10-100 μg/l) with concentrations of less than 20 μg/l (Doyle *et al* 1994). The serum ferritin concentrations of the total group in the London study were comparable with those of the previously mentioned Irish study (Doyle *et al* 1994; Armstrong 1989).

Reports of folate and folic acid intakes and status among young adolescents are lacking. A study of 12 and 15-year-old boys and girls, from Northern Ireland, found that the mean daily intake of folate fell well below the estimated average requirements in all age-sex groups, except for 15 year old boys (McNulty *et al* 1996). The mean nutrient intake of London schoolchildren (*n* 66), aged 12-13 years were also found to be lower than reference values among both boys and girls with 13% of the girls reporting a folic acid intake less than the lower reference nutrient intake (Doyle *et al* 1994). Frank deficiency (less than 7.0 nmol/L) was not identified from blood tests of serum folate, an indicator of recent intake, among this group but 41% were identified as having a moderate risk of deficiency with serum folate concentrations of 7-12 nmol/L (Doyle *et al* 1994).

1.5.4.1 Factors associated with the development of iron deficiency.

Dietary iron is consumed in two forms; non-haem iron and haem iron. Food contains primarily the non-haem iron form of inorganic iron III (ferric) complexes, and is supplied by bread, cereals, fruits and vegetables, with a smaller amount present in the haem proteins, haemoglobin, and myoglobin, which are present in meat and meat products (Dallman *et al* 1980). Non-haem iron in food is broken down during digestion, and is partly reduced to the more readily absorbed iron II (ferrous) form (Dallman *et al* 1980). Absorption of non-haem iron is affected by other dietary constituents. For example, ascorbic acid enhances assimilation, whereas dietary phophates, oxalates, calcium, food fibre and certain metal chelators decrease absorption

(Dallman *et al* 1980; Olmedilla and Granado 2000). Haem iron is readily absorbed and dietary constituents that decrease the absorption of non-haem iron appear to have significantly less effect on haem iron (Dallman *et al* 1980).

Menstrual iron losses account for a significant proportion of the iron requirement of menstruating females and these losses are not normally distributed (Department of Health 1991). In adolescent girls, the onset of regular menstruation poses an additional stress on their ability to achieve iron balance in addition to the demands placed by growth (Fogelholm *et al* 1993).

Being a vegetarian confers an increased likelihood of having low haemoglobin levels (an indication of anaemia) amongst white girls, probably because most of these girls may not have found suitable dietary alternatives which provide the iron previously provided by meat and meat products (Nelson *et al* 1994). The iron intake of self-professed vegetarian Irish schoolgirls (*n* 21, mean age 15 years) was found to be well below the estimated average requirement for teenage girls (Ryan *et al* 1996). In addition, 'reduced meat eaters' (*n* 42) were found to be more likely to want to be slimmer and to have tried losing weight compared to 'meat eaters' (*n* 138; 75% vs. 61% and 80% vs. 62%, respectively) implying that meat avoidance is linked with a desire to reduce body weight (Ryan *et al* 1996).

1.5.4.2 Measurement of iron status.

Several characteristics can be used to assess body iron status, including low mean corpuscular volume (MCV), low haemoglobin, low serum ferritin, and low serum iron concentrations with higher than normal total iron-binding capacity; the absence from a bone-marrow aspirate of stainable iron; and high concentrations of soluble serum transferrin receptors (Provan and Weatherall 2000).

Serum ferritin is an acute phase protein and can be falsely elevated in the presence of infection, and so, until recently, the only true measure of iron status was the bone marrow aspirate (Provan and Weatherall 2000). The concentration of soluble serum transferrin receptor is useful in the diagnosis of iron deficiency as it is not compromised by inflammatory, infectious or malignant disease (Akesson *et al* 1998). In adults, the soluble transferrin receptor, expressed in greater quantities in iron deficiency, replaces serum ferritin as the primary predictor of iron deficiency anaemia being easier to assess than the bone-marrow aspirate as the 'gold standard' of iron status (Provan and Weatherall 2000).

Serum ferritin has been shown to reflect total iron stores and is a practical marker to assess in children as it can be measured from small amounts of blood, shows no diurnal variation, and children are not required to fast before blood sampling, unlike serum iron and total iron binding concentration measurements (Duggan *et al* 1991). Furthermore, the determination of serum iron and total iron binding capacity, from which transferrin saturation is calculated, requires a greater amount of blood that is not readily obtained except by venepuncture (Dallman *et al* 1980).

Values for both haemoglobin and mean corpuscular volume undergo marked changes during development and therefore, haemoglobin and MCV centiles have been developed as reference values (Dallman and Siimes 1979). These centiles were developed from multiple samples of white children from both the USA and Finland, which excluded results of children with an identified cause of anaemia or iron deficiency in all but one of the samples where additional laboratory tests did not allow such distinction (Dallman and Siimes 1979). By combining the MCV with the haemoglobin in screening for iron deficiency the accuracy of diagnosis is increased because it is less likely that both values would be in the lowest portion of the distribution curve by chance (Dallman and Siimes 1979).

1.5.4.3 Implications of iron deficiency during childhood and young adolescence.

Iron deficiency and iron deficiency anaemia are established causes of reduced immune response (Dallman 1987). Both conditions are also known to be associated, among schoolchildren, with less than optimal behaviour and poorer performance in intelligence tests (Pollitt 1990). Physical performance may be compromised, among young adolescent girls, at mild levels of anaemia (Nelson *et al* 1994). There is anecdotal evidence to suggest that those with low haemoglobin levels reduce their activity levels in order to avoid precipitating clinical symptoms of anaemia (e.g., tiredness, lassitude, palpitations) and thus appear to function normally albeit at reduced levels of activity (Nelson *et al* 1994). Anaemia in adolescent girls that persists into their reproductive years may have important long-term implications for their offspring. Low haemoglobin in pregnancy is associated with a raised placenta:birth weight ratio and this may be a predictor of high blood pressure in adult life (Barker *et al* 1990; Godfrey *et al* 1991).

During male puberty, rapid growth of the body and muscles (especially at the end of puberty) requires a great deal of iron, and the achievement of adult testosterone concentrations is associated with an increase in erythropoiesis and in haemoglobin concentration (Thomsen *et al* 1986). Growth in body height, and especially in weight and muscles, causes a marked increase in blood volume and consequently places heavy demands on iron availability (Anttila and Siimes 1996). In individuals with active physical training the rise in red blood cell volume may result in an additional requirement for iron (Anttila and Siimes 1996).

1.5.4.4 Factors associated with folate intake.

Folate is one of the B vitamins, the synthetic form of which is folic acid. The main naturally occurring forms of folate predominate in fresh food (liver, yeast extract and dark green leafy vegetables), but on storage these slowly break down and oxidise to less available folates (Department of Health 1991). Synthetic folic acid (a stable oxidised form often used to correct folate deficiency) is considered to be more bioavailable than natural folate (Krishnaswamy and Nair 2001).

Folate deficiency can arise in a variety of settings such as low dietary intake, increased demands during growth periods, lactation and pregnancy, malabsorption, conditions of haemolysis such as haemolytic anaemias and malignancy such as leukaemias. Drug induced folate deficiency is encountered in epileptics, ulcerative colitis, etc. (Krishnaswamy and Nair 2001). Rapidly dividing tissues during the adolescent growth spurt increases requirements for folate (Alonso-Aperte and Varela-Moreiras 2000).

Breakfast cereals have been found to be the only foods eaten by a substantial proportion of schoolchildren which are fortified with a wide range of micronutrients (McNulty *et al* 1996). Indeed, a study among 17-40 year old Northern Irish women (n 51) found that providing 100μg folic acid per day via fortified foods had significant beneficial effects on red cell folate (Cuskelly *et al* 1999). Among Northern Irish children, folate intakes were found to increase significantly with increasing consumption of fortified breakfast cereals demonstrating the potential of fortification to make a valuable contribution to overall folate intakes; but it was found that the levels of fortification were not high enough to ensure that the recommended intakes were reached by adolescent girls (McNulty *et al* 1996). Furthermore, it has been noted that there is an apparent trend towards decreased consumption of breakfast cereal in older adolescents (Department of Health 1989). The potential beneficial effects of folic acid fortification would seem to be limited by time constraints imposed by increasing age; a cause of concern considering that the desired effect of fortification is to limit the development of chronic disease later in life.

It has been suggested that an increase in dietary fibre intake is associated with an increase in serum folate concentration (Houghton *et al* 1997). It is proposed that this is due, at least in part, to changes in the intestinal environment that promote a net increase in microbiotic biosynthesis of folate (Houghton *et al* 1997). The stimulation of bacterial growth by the fermentation of increased quantities of dietary fibre may, in turn, enhance net microbial biosynthesis of folate (Houghton *et al* 1997). Therefore, dietary manipulations that increase biosynthesis of folate in the large intestine may enhance folate status (Houghton *et al* 1997).

1.5.4.5 Measurement of folate status.

Biochemical assessment of folate nutritional status is most commonly done by measuring serum and red blood cell folate levels (Krishnaswamy and Nair 2001). Serum folate essentially reflects recent intake and red cell folate levels represent longterm tissue stores (Krishnaswamy and Nair 2001). It is generally accepted that red cell folate levels of greater than 150μg/L are considered satisfactory, 100 to 150μg/L are considered low and suggestive of risk and values lower than these indicate clear deficiency (Krishnaswamy and Nair 2001).

Microbiological methods or radioassays may be used to in the analysis of serum and red cell folate (Molloy and Scott 1997). The microbiological method remains for most investigations the 'gold standard' and the method of choice (Molloy and Scott 1997). Where it used to be difficult to set up, maintain, and was slow in obtaining results, it has now been refined and automated to such an extent that it is easy to perform, reliable to maintain, and considerably less costly, particularly where large numbers of samples are involved (Molloy and Scott 1997).

1.5.4.6 Implications of folate deficiency.

The main implication of folate deficiency during childhood and young adolescence is the onset of chronic disease, such as ischaemic heart disease and cancer, in middle age.

Currently, from dietary intake studies and folate status in pregnant women and children, it has been observed that the incidence of sub-clinical forms of folic acid deficiency is high in these vulnerable groups (Krishnaswamy and Nair 2001).

Folate, with vitamin B_{12}, is closely involved in DNA synthesis and deficiency of either vitamin produces similar clinical and laboratory features (Wickramasinghe 1995; Provan and Weatherall 2000). Folates are involved in single carbon transfer reactions, especially in the synthesis of purines, pyrimidines, glycine and methionine (Department of Health 1991). Rapidly regenerating tissues such as the intestinal mucosa may suffer, while in babies and young children, growth may be affected (Department of Health 1991). Frank deficiency of folate or vitamin B_{12} will lead to megaloblastic anaemia, whereas milder deficiencies are associated with a predisposition to thrombosis (Provan and Weatherall 2000).

Folic acid may also be associated with a variety of pregnancy complications such as spontaneous abortions, bleeding, abruptio placenta and pre-eclampsia (Krishnaswamy and Nair 2001). Pre-conceptual administration can reduce women's risk of having a fetus or infant with a neural tube defect (NTD; Krishnaswamy and Nair 2001). Most teenage pregnancies are unplanned (therefore folic acid supplementation is unlikely to be in place), and the incidence in NTD appears to be higher in younger (and older) mothers than the general population of women in their reproductive years and is a significant public health concern (Department of Health 1992). The recommendation for the prevention of first occurrence of NTD in women with no previous history (representing 95% of all cases) is 400 μg/day folic acid, over and above current intakes of the vitamin (Department of Health 1992). The recommendation of 4-5mg folic acid/d to prevent NTD recurrences is clearly achievable only through supplementation (Cuskelly *et al* 1999). The recommended intakes of folate among women of child-bearing age requires a significant increase in food folate given that the current mean daily intake of folate among 18-35 year old Irish women is estimated to be 247μg (O'Brien *et al* 2001). As compliance with supplementation has been found to be problematic among the general target population (Scott *et al* 1994), food fortification is seen by many as the only alternative likely to succeed (Cuskelly *et al* 1999).

Methionine, an essential amino acid for humans that is usually present in the diet in excess of approximately 60% over estimated requirements and this excess is degraded via the methylation cycle to homocysteine. If there is underprovision of dietary folate a reduction in the methylation cycle is caused that produces an elevation of plasma homocysteine. In the liver folate (in the cofactor form of 5-methylenetetrahydrofolate) is involved in the remethylation of the homocysteine produced in the methylation cycle back to methionine (Scott 1999). Even moderate elevation of plasma homocysteine to levels seen in subjects with a folate status hitherto not considered as being deficient may put subjects at increased long-term risk of cardiovascular disease or stroke (Wald *et al* 1998).

1.6 A changing emphasis on sugar intake and dental caries risk.

The process of dental caries is very simple: dietary sugar is fermented and metabolised by bacteria in the plaque layer on teeth and these acids dissolve the mineral in the teeth. When enough mineral has been dissolved, a hole develops (Rugg-Gunn 2001). Fermentable sugars predominately consist of non-milk extrinsic sugars include those sugars that are not found in milk, fruit or vegetables but are added by the manufacturer, cook or consumer to food. Total fermentable sugars in the particles of high-starch foods (for example, potato crisps, salted crackers, etc.) were found to be similar to those for high-sucrose confectionery products and to be capable of promoting plaque acidogenesis (Kashket *et al* 1996). It is recommended that consumption of "added sugars" does not exceed 10% of energy (Department of Health 1991).

Unless dental caries is being specifically investigated, studies documenting dietary intakes will rarely, if at all, distinguish between the sub-classes giving only a total sugar consumption in terms of percentage of total energy. The main sources of non-milk extrinsic sugars are reported to be confectionery and soft drinks, consumption of which was reported to have increased over a ten year period among young English adolescents (Rugg-Gunn *et al* 1993). Using the same methods of assessment, the amount of total sugars consumed by these adolescents (*n* 379, age 12 years) was estimated and reported to be unchanged but the consumption of non-milk extrinsic sugars had increased whereas milk and intrinsic sugar consumption decreased from 1980 to 1990 (Rugg-Gunn *et al* 1993). A recent report on diet and dental health by the British Nutrition Foundation reviewed the issue of whether it is the frequency or amount of sugars consumed that influences dental caries. It concluded that both are important and that as they are both highly positively correlated, efforts to control one will control the other (Moynihan 2000).

Since the early 1970s, dental caries has declined sharply, and this has been largely due to the widespread use of fluoride (Downer 1998). This observation is made despite the fact that total sugar consumption has remained constant while sugar drinks and confectionery products have increased in most industrialised countries. As a result, the sugar-caries relationship cannot be established in most industrialised countries and the dietary factor is not as preponderant in the caries process as it used to be (Kandelman 1997). It is now accepted that people who receive appropriate systemic and topical fluoride supplements and follow regular oral hygiene measures can safely use dietary carbohydrates but it is still recommended that sugary snacks and drinks are taken a limited number of times throughout the day (Kandelman 1997; Nutrition Advisory Committee 1995).

1.6.1 Socio-economic class may predict dental caries.

Social disadvantage is reported to be a major determinant of caries prevalence in children and adolescents (Evans *et al* 1996; Kinirons and Stewart 1998; Gibson and Williams 1999). It is often assumed that social class inequalities in dental health are largely caused by differences in behaviours such as toothbrushing habit (with a fluoride toothpaste), sweet consumption and visits to the dentist (Gibson and Williams 1999). In stepwise logistic regression, the strength of the association between social class and caries experience was twice that between toothbrushing and caries and nearly three times that between sugar confectionery and caries among pre-school English children (*n* 1450; Gibson and Williams 1998). Although reductions in dental caries have been reported among all social groups within fluoridated areas, this reduction was not enough to obviate the disadvantage caused by social background (Evans *et al* 1996). This is possibly related to differences in the uptake of dental treatment between social classes. Socially disadvantaged Northern Irish adolescents were reported to have significantly higher levels of untreated caries and to visit the dentist the least often (Kinirons and Stewart 1998). Or in other words, those with the highest requirement for dental treatment were the least likely to avail of it.

1.7 Body weight, nutrition, and dental health of young Dublin adolescents.

It is ten years since the nutritional intake among Irish 12-15-year-olds was assessed and there is no published data among younger Irish groups. Children are a distinctly different group from adults. They are physically and mentally developing and, subsequently, have different nutrient requirements and cognitive abilities. An adequate energy intake is important to ensure that the maximum genetic potential is reached during adolescent maturation and growth, and poor iron and folate intakes represent rate-limiting steps in this process. Adolescence also represents the emergence of children into adulthood and is a time when lifelong dietary habits are begun through expressions of independence. Indeed, nutritional status during adolescence seems to determine, to an extent, risk of chronic diseases in adulthood (Pi-Sunyer 1991; Neumark-Sztainer *et al* 1999). It is recognised that child obesity has increased worldwide but at what rate this has occurred within the Irish child population is not known. Indeed, it is important to collect regular measurements of weight and height to establish secular trends. Investigative approaches, therefore, have to be tailored to gather information that accurately represents the age group being examined.

With this in mind, the specific objectives of this study among young Irish adolescents included:

- Development of age-specific tools of methodology, mainly a questionnaire and food diary.
- An estimation of the prevalence of fear of fatness and weight loss practices.
- Identification of the difficulties involved in estimating the current weight status using available methods of cut-offs of Body Mass Index and Actual Relative Weight.
- Establishing the secular trend in the prevalence of obesity over the last ten years and to compare with those from other developed countries.
- Assessment of the adequacy of reported daily nutrient intakes by comparison to published recommended nutrient allowances for Ireland.
- An investigation of whether fear of fatness had an effect on reported energy intakes.
- Identification of the prevalence of iron and folate deficiency anaemias among apparently healthy schoolchildren.
- An examination of whether socio-economic class, dental hygiene practices or cariogenic foods are associated with dental caries.

1.8 References

Akesson A, Bjellerup P, Berglund M, Bremme K, Vahter M (1998): Serum transferrin receptor: a specific marker of iron deficiency in pregnancy. *American Journal of Clinical Nutrition.* **68,** 1241-1246

Alonso-Aperte E, Varela-Moreiras G (2000): Drugs-nutrient interactions: a potential problem during adolescence. *European Journal of Clinical Nutrition.* **54,** Suppl 1, S69-S74

Ames BN (1999): Micronutrient deficiencies: a major cause of DNA damage. *Annals of New York Academy of Sciences.* **889,** 87-106

Andersen RE, Crespo CJ, Bartlett SJ, Cheskin LJ, Pratt M (1998): Relationship of physical activity and television watching with body weight and level of fatness among children: Results from the Third National Health and Nutrition Examination Survey. *Journal of the American Medical Association.* **279,** 938-942

Anttila R, Siimes MA (1996): Serum transferrin and ferritin in pubertal boys: relations to body growth, pubertal stage, erythropoiesis, and iron deficiency. *American Journal of Clinical Deficiency.* **63,** 179-183

Armstrong PL (1989): Iron deficiency in adolescents. *British Medical Journal.* **298,** 499

Armstrong N, Balding J, Gentle P, Kirby B (1990): Patterns of physical activity among 11 to 16 year old British children. *British Medical Journal.* **301,** 203-205

Bandini LG, Schoeller DA, Cyr HN, Dietz WH (1990): Validity of reported energy intake in obese and non-obese adolescents. *American Journal of Clinical Nutrition.* **52,** 421-425

Bandini LG, Vu D, Must A, Cyr H, Goldberg A, Dietz WH (1999): Comparison of high-calorie, low-nutrient-dense food consumption among obese and non-obese adolescents. *Obesity Research.* **7(5),** 438-443

Barker DJP, Bull AR, Osmond C, Simmonds SJ (1990): Fetal and placental size and risk of hypertension in adult life. *British Medical Journal.* **301,** 259-262

Benton D, Cook R 91991): Vitamin and mineral supplements improve the intelligence scores and concentration of six year old children. *Personality and Individual Differences.* **12,** 1151-1158

Benton D (1992): Vitamin-mineral supplements and intelligence. *Proceedings of the Nutrition Society.* **51,** 295-302

Berenson GS (1980): Cardiovascular risk factors in children. In: The Early Natural History of Athersclerosis and Essential Hypertension. New York, Oxford University Press.

Berkey CS, Rockett HRH, Field AE, Gillman MW, Frazier AL, Camargo CA, Colditz GA (2000): Activity, dietary intake, and weight changes in a longitudinal study of preadolescent and adolescent boys and girls. *Pediatrics.* **105(4),** URL: http://www.pediatrics.org/cgi/content/full/105/4/e56

Berner LA, Clydesdale FM, Douglass JS (2001): Fortification contributed greatly to vitamin and mineral intakes in the United States, 1989-1991. *Journal of Nutrition.* **131,** 2177-2183

Beunen GP, Malina RM, Lefevre JA, Claessens AL, Renson R, Vanreusel B (1994): Adiposity and biological maturity in girls 6-16 years of age. *International Journal of Obesity.* **18,** 542-546

Bhan MK, Bhandari N (1998): The role of zinc and vitamin A in persistent diarrhoea among infants and young children. *Journal of Pediatric Gastroenterology and Nutrition.* **26,** 446-453

Bini V, Celi F, Berioli MG, Bacosi ML, Stella P, Giglio P, Tosti L, Falorni A (2000): Body mass index in children and adolescents according to age and pubertal stage. *European Journal of Clinical Nutrition.* **54,** 214-218

Birch LL, Fisher JO (1998): Development of eating behaviours among children and adolescents. P*ediatrics.* **101,** 539-549

Black AE, Goldberg GR, Jebb SA, Livingstone MBE, Cole TJ, Prentice AM (1991): Critical evaluation of energy intake data using fundamental principals of energy physiology: 2, Evaluating the results of published surveys. *European Journal of Clinical Nutrition.* **45,** 583-599

Bonadonna RC, Groop L, Kisemer N, Ferrannini E, DelPrato S, DeFronzo RA (1990): Obesity and insulin resistance in humans: a dose response study. *Metabolism.* **39,** 452-459

Brooks-Gunn J, Warren MP (1985): The effects of delayed menarche in different contexts: dance and nondance students. *Journal of Youth and Adolescence.* **14,** 285-300

Caprio S, Hyman LD, McCarthy S, Lange R, Bronson M, Tamborlane WV (1996): Fat distribution and cardiovascular risk factors in obese adolescent girls: importance of the intra-abdominal fat depot. *American Journal of Clinical Nutrition.* **64,** 12-17

Clausen T, Dorup I (1998): Micronutrients, minerals and growth control. In: *Role of Trace Elements for Health Promotion and Disease Prevention,* ed. B Sandstrom & P Walter. Bibl. Nutr. Dieta. **54,** pp84-92. Basel: Karger

Cole TJ, Bellizzi MC, Flegal KM, Dietz WH (2000): Establishing a standard definition for child overweight and obesity worldwide: international survey. *British Medical Journal.* **320,** 1240-1243

Crawford PB, Obarzanek E, Morrison J, Sabry ZI (1994): Comparative advantage of 3-day food records over 24-hour recall and 5-day food frequency validated by observation of 9- and 10-year-old girls. *Journal of the American Dietetic Association.* **94,** 626-630

Crawley HF, Shergill-Bonner R (1995): The nutrient and food intakes of 16-17 year old female dieters in the UK. *Journal of Human Nutrition and Dietetics.* **8,** 25-34

Cunningham K, Lee P (1990): *Irish National Nutrition Survey*. The Irish Nutrition and Dietetic Institute, Dublin

Cuskelly GJ, McNulty H, Scott JM (1999): Fortification with low amounts of folic acid makes a significant difference in folate status among young women: implications for the prevention of neural tube defects. *Americnan Journal of Clinical Nutrition.* **70,** 234-9

Dallman PR, Siimes MA (1979): Percentile curves for haemoglobin and red cell volume in infancy and childhood. *Journal of Pediatrics.* **94,** 26-31

Dallman PR, Siimes MA, Stekel A (1980): Iron deficiency in infancy and childhood. *American Journal of Clinical Nutrition.* **33,** 86-118

Dallman PR (1987): Iron deficiency and the immune response. *American Journal of Clinical Nutrition.* **46,** 329-334

Daniels SR, Morrison JA, Sprecher DL, Khoury P, Kimball TR (1999): Association of body fat distribution and cardiovascular risk factors in children and adolescents. *Circulation.* **99,** 541-545

Daniels SR, Khoury PR, Morrison JA (1997): The utility of body mass index as a measure of body fatness in children and adolescents: differences by race and gender. *Pediatrics.* **99,** 804-807

Davis D, Apley G, Fill G, Grimaldi C (1978): Diet and retarded growth. *British Medical Journal.* **1,** 539-542 de Onis M, Blossner M (2000): Prevalence and trends of overweight among preschool children in developing countries. *American Journal of Clinical Nutrition.* **72**, 1032-1039

Department of Health (1989): *The Diets of British Schoolchildren.* Report on Health and Social Subjects No. 36. London: HMSO

Department of Health (1991): *Dietary Reference Values for Food Energy and Nutrients for the United Kingdom.* Report on Health and Social Subjects No. 41. London: HMSO

Department of Health (1992): *Folic Acid and the Prevention of Neural Tube Defects.* Report from an expert advisory group. London: Department of Health

Dietz WH (1994): Critical periods in childhood for the development of obesity. *American Journal of Clinical Nutrition.* **59**, 955-959

Docio S, Riancho JA, Perez A, Olmos JM, Amado JA, Gonzalez-Macias J (1998): Seasonal deficiency of vitamin D in children: a potential target for osteoporosis-preventing strategies? *Journal of Bone and Mineral Research.* **13(4),** 544-548

Domel SB, Thompson WO, Baranowski T, Smith AF (1994): How children remember what they have eaten. *Journal of the American Dietetic Association.* **94,** 1267-1272

Downer MC (1998): The changing pattern of dental disease over 50 years. *British Dental Journal.* **185,** 36-41

Doyle W, Jenkins S, Crawford MA, Puvandendran (1994): Nutritional status of schoolchildren in an inner city area. *Archives of Disease in Chilhood.* **70,** 376-381

Duggan MB, Steel G, Elyws G, Harbottle L, Noble C (1991): Iron status, energy intake, and nutritional status of healthy young adults. *Archives of Diseases in Childhood.* **66,** 1386-1389

Eck LH, Klesges RC, Hanson CL, Slawson D (1992): Children at familial risk of obesity: an examination of dietary intake, physical activity and weight status. *International Journal of Obesity and Related Metabolic Disorders.* **16,** 71-78

Emmons L, Hayes M (1973): Accuracy of 24-hr. recalls of young children. *Journal of the American Dietetic Association.* **62,** 409-415

Epstein LH, Coleman KJ, Myers MD (1996): Exercise in treating obesity in children and adolescents. . *Medicine and Science in Sports and Exercise..* **28,** 428-435

Evans DJ, Rugg-Gunn AJ, Tabari ED, Butler T (1996): The effect of flouridation and social class on caries experience in 5-year-old Newcastle children in 1994 compared with results over the previous 18 years. *Community Dental Health.* **13,** 5-10

Falorni A, Bini V, Cabiati V, Papi F, Arzano F, Celi F, Sanasi M (1997): Serum levels of type I procollagen C-terminal propeptide, insulin-like growth factor-I (IGF-I), and IGF-binding protein-3 in obese children and adolescents: relationship to gender, pubertal development, growth, insulin and nutritional status. *Metabolism.* **46,** 862-871

Feldman W, Feldman E, Goodman JT (1988): Culture versus biology: children's attitudes toward thinness and fatness. *Pediatrics.* **81**, 190-194

Field AE, Camargo CA, Taylor CB, Berkey CS, Roberts SB, Colditz GA (2001): Peer, parent, and media influences on the development of weight concerns and frequent dieting among preadolescent and adolescent girls and boys. *Pediatrics.* **107,** 54-60

Fisher JO, Johnson RK, Lindquist C, Birch LL, Goran MI (2000): Influence of body composition on the accuracy of reported energy intake in children. *Obesity Research.* **8(8),** 597-603

Fletcher GF, Balady G, Blair SN, Blumenthal J, Caspersen C, Chaitman B, Epstein S, Sivarajan Froelicher ES, Froelicher VF, Pina IL, Pollock ML (1996): Statement on exercise: benefits and recommendations for physical activity programmes for all Americans: a statement for health professionals by the Committee on Exercise and Cardiac Rehabilitation of the Council on Clinical Cardiology, American Heart Association. *Circulation.* **94,** 857-862

Flynn MAT (1997): Fear of fatness and adolescent girls: implications for obesity prevention. *Proceedings of the Nutrition Society.* **56,** 305-317

Fogelholm M, Alopaeus K, Silvennoinen T, Teirila J (1993): Factors affecting iron status in non-pregnant women from urban South Finland. *European Journal of Clinical Nutrition.* **47,** 567-574

Fox KR, Peters DM, Sharpe P, Bell M (2000): Assessment of abdominal fat development in young adolescents using magnetic resonance imaging. *International Journal of Obesity.* **24**, 1653-1659

Freedman DS, Srinivasan SR, Harsha DW, Webber LS, Berensen GS (1989): Relation of body fat patterning to lipid and lipoprotein concentrations in children and adolescents; the Bogalusa Heart Study. *American Journal of Clinical Nutrition.* **50,** 930-939

Freedman DS, Srinivasan SR, Valdez RA, Williamson DF, Berenson GS (1997): Secular increases in relative weight and adiposity among children over two decades: the Bogalusa Heart Study. *Pediatrics.* **99(3),** 420-426

French SA, Perry CL, Leon GR, Fulkerson JA (1995): Dieting behaviours and weight change history in female adolescents. *Health Psychology.* **14,** 548-555

Frisch RE (1989): Fatness, menarche, and female fertility. P*erspectives in Paediatric Medicine.* **28,** 611-633

Gardner RM, Sorter RG, Friedman BN (1997): Developmental changes in children's body images. *Journal of Social Behaviour and Personality.* **12,** 1019-1036

Gardner RM, Stark K, Friedman BN, Jackson NA (2000): Predictors of eating disorder scores in children ages 6 through 14: A longitudinal study. *Journal of Psychosomatic Research.* **49,** 199-205

Garfinkel PE, Garner DM (1982): Anorexia *Nervosa.* Brunner/Mazel; New York

Gazzangia JM, Burns TL (1993): Relationship between diet composition and body fatness with adjustment for resting energy expenditure and physical activity, in preadolescent children. *American Journal of Clinical Nutrition.* **58,** 21-28

Gibson S, Williams S (1999): Dental caries in pre-school children: associations with social class, toothbrushing habit and consumption of sugars and sugar-containing foods. Further analysis of data from the National Diet and Nutrition Survey of children aged 1.5-4.5 years. *Caries Research.* **33,** 101-113

Gillman MW, Rifas-Shiman SL, Frazier L, Rockett HRH, Camargo CA, Field AE, Berkey CS, Colditz GA (2000): Family dinner and diet quality among older children and adolescents. *Archives of Family Medicine.* **9,** 235-240

Giovanni M, Agostoni C, Gianni M, Bernardo L, Riva E (2000): Adolescence: maconutrient needs. *European Journal of Clinical Nutrition.* **54,** Suppl 1, S7-S10

Godfrey KM, Redman CWG, Barker DJP, Osmond C (1991): The effect of maternal anaemia and iron deficiency on the ratio of fetal weight to placental weight. *British Journal of Obstetrics and Gynaecology.* **98,** 886-891

Goldberg GR, Black AE, Jebb SA, Cole TJ, Murgatroyd R, Coward WA, Prentice AM (1991): Critical evaluation of energy intake data using fundamental principals of energy physiology: 1. Derivation of cut-off limits to identify under-recording. *European Journal of Clinical Nutrition.* **45,** 569-581

Gong EJ, Heald FP (1994): Diet, nutrition and adolescence. In: *Modern Nutrition in Health and Disease* (8th edn), ed. ME Shils, JA Olsen, M Shike. Lea & Febiger: Philadelphia PA, pp 759-769

Goran MI, Gower BA, Treuth M, Nagy TR (1998*a*): Prediction of intra-abdominal and subcutaneous abdominal adipose tissue in healthy pre-pubertal children. *International Journal of Obesity.* **22,** 549-558

Goran MI, Gower BA, Nagy TR, Johnson RK (1998*b*): Developmental changes in energy expenditure and physical activity in children: evidence for a decline in physical activity in girls before puberty. *Pediatrics.* **101,** 887-891

Guo SS, Huang C, Maynard LM, Demerath, E, Towne B, Chumlea WC, Siervogel RM (2000): Body mass index during childhood, adolescence and young adulthood in relation to adult overweight and adiposity: the Fels Longitudinal Study. *International Journal of Obesity.* **24**, 1628-1635

Himes JH, Dietz WH (1994): Guidelines for overweight in adolescent preventive services: recommendations from an expert committee. *American Journal of Clinical Nutrition.* **59,** 307-316

Houghton LA, Green TJ, Donovan UM, Gibson RS, Stephen AM, O'Connor DL (1997): Association between dietary fibre intake and the folate status of a group of female adolescents. *American Journal of Clinical Nutrition.* **66,** 1414-1421

Hughes JM, Li L, Chinn S, Rona RJ (1997): Trends in growth in England and Scotland, 1972 to 1994. *Archives of Diseases of Childhood.* **76,** 182-189

Hurson M, Corish C (1997): Evaluation of lifestyle, food consumption and nutrient intake patterns among Irish teenagers. *Irish Journal of Medicine and Science.* **166(4),** 225-230

Janz KF, Dawson JD, Mahony LT (2000): Tracking physical fitness and physical activity from childhood to adolescence: the Muscatine study. *Medicine and Science in Sports and Exercise.* **32(7),** 1250-1257

Kandelman D (1997): Sugar, alternative sweeteners and meal frequency in relation to caries prevention: new perspectives. *British Journal of Nutrition.* **77,** S121-S128

Kashket S, Zhang J, Van Houte J (1996): Accumulation of fermentable sugars and metabolic acids in food particles that become entrapped on the dentition. *Journal of Dental Research.* **75,** 1885-1891

Kemper HC, Post GB, Twisk JW, van Mechelen W (1999): Lifestyle and obesity in adolescence and young adulthood: results from the Amsterdam Growth and Health Longitudinal Study (AGAHLS). *International Journal of Obesity.* **23** (Suppl 3): S34-S40

Kendler KS, Maclean C, Neale M, Kessler R, Heath A, Eaves L (1991); The genetic epidemiology of bulimia nervosa. *American Journal of Psychiatry.* **148,** 1627-1637

Kikuchi D, Srinivasan SR, Harsha D, Webber LS, Sellers TA, Berenson GS (1992): relation of serum lipoprotein lipids and apolipoproteins to obesity in children: the Bogalusa Heart Study. *Previews in Medicine.* **21,** 177-190

Killen JD, Taylor B, Telch MJ, Saylor KE, Maron DJ, Robinson TN (1986): Self-induced vomiting and laxative and diuretic use among teenagers. Precursors of the binge-purge syndrome? *Journal of the American Medical Association.* **255,** 1447-1449

Kinirons MJ, Stewart C (1998): Factors affecting levels of untreated caries in a sample of 14-15-year-old adolescents in Northern Ireland. *Community Dentistry and Oral Epidemiology.* **26,** 7-11

Krishnaswamy K, Nair KM (2001): Importance of folate in human nutrition. *British Journal of Nutrition.* **85,** Suppl. 2, S115-S124

Kuczmarski RJ (1993): Trends in body composition for infants and children in the US. *Critical Reviews in Food Science and Nutrition.* **33(4/5)**, 375-387

Kuczmarski RJ, Ogden CL, Grummer-Strawn LM, Flegal KM, Guo SS, Wei R, Curtin LR, Roche AF, Johnson CL. (2000): CDC growth charts: United States. Advance data from vital and health statistics; no.314. Hyattsville, Maryland: National Center for Health Statistics URL: http://www.cdc.gov/nchs/

Lake JK, Power C, Cole TJ (1997): Child to adult body mass index in the 1958 British birth cohort: Associations with parental obesity. *Archives of Diseases in Childhood.* **77,** 376-381

Lake JK, Power C, Cole TJ (1997*b*): Women's reproductive health: the role of body mass index in early and adult life. *International Journal of Obesity.* **21(6),** 432-438

Lehtonen-Veromaa M, Mottonen T, Irjala K, Karkkainen M, Lamberg-Allardt C, Hakola P, Viikari J (1999): Vitamin D intake is low and hypovitaminosis D common in healthy 9- to 15-year-old Finnish girls. *European Journal of Clinical Nutrition.* **53,** 746-751

LeStunff C, Bougneres P (1994): Early changes in postprandial insulin secretion, not insulin sensitivity, characterise juvenile obesity. *Diabetes.* **43,** 696-702

Lewis G, Pelosi AJ, Glover E, Wilkinson G, Stansfield SA, Williams P, *et al* (1998): The development of a computerised assessment for minor psychiatric disorders. *Psychology and Medicine.* **18,** 737-45

Ley CJ, Lees B, Stevenson JC (1992): Sex- and menopause-associated changes in body-fat distribution. *American Journal of Clinical Nutrition.* **55,** 950-954

Lips P (1996): Vitamin D deficiency and osteoporosis: The role of vitamin D deficiency and treatment with vitamin D analogues in the prevention of osteoporosis-related fractures. *European Journal of Clinical Investigation.* **26,** 436-42

Lissau I, Breum L, Sorensen TIA (1993): Maternal attitude to sweet eating habits and risk of overweight in offspring: a ten-year prospective population study. *International Journal of Obesity.* **17,** 125-129

Livingstone MBE, Prentice AM, Coward WA, Strain JJ, Black AE, Davies PSW, Stewart CM, McKenna PG, Whitehead RG (1992): Validation of estimates of energy intake by weighed dietary record and diet history in children and adolescents. *American Journal of Clinical Nutrition.* **56,** 29-35

Livingstone MBE (2000): Epidemiology of childhood obesity in Europe. *European Journal of Pediatrics.* **159,** S14-S34

Livingstone MBE, Robson PJ (2000): Measurement of dietary intake in children. *Proceedings of the Nutrition Society.* **59,** 279-293

Loucks AB (1988): Osteoporosis prevention begins in childhood. In: Brown EW, Bravta CF (eds) Competitive sports for children and youth: an overview of research and issues. *Human Kinetics.* Champaign, Illinois, 213-223

McElligott-Tangney P, Morrissey P (2001): Nutrition and lifestyle survey of 15-17 year old second level pupils in the Cork city area. *Irish Medical Journal.* **94(2)** URL: http://www.imj.ie/issue31/papers/paper3.html

McNulty H, Eaton-Evans J, Cran G, Woulahan G, Boreham C, Savage J, Fletcher R, Strain JJ (1996): Nutrient intakes and impact of fortified breakfast cereals in schoolchildren. *Archives of the Diseases of Childhood.* **75,** 474-481

Maffeis C, Pinelli L, Schutz Y (1996): Fat intake and adiposity in 8 to 11-year-old obese children. *International Journal of Obesity and Related Metabolic Disorders.* **20,** 170-174

Maffeis C, Grezzani A, Pietrobelli A, Provera S, Tato L (2001): Does waist circumference predict fat gain in children? *International Journal of Obesity and Related Metabolic Disorders* **25,** 978-983

Malina RM (1996): Tracking of physical activity and physical fitness across the lifespan. *Research Quarterly for Sport and Exercise.* **67,** 48-57

Martinez JA, Kearney JM, Kafatos A, Paquet S, Martinez-Gonzales MA (1999): Variables independently associated with self-reported obesity (BMI > 30kg/m^2) in the European Union population. *Public Health Nutrition.* **2,** 125-134

Mellin LM, Irwin CE, Scully S (1992): Prevalence of disordered eating in girls: A survey of middle-class children. *Journal of the American Dietetic Association.* **92(7),** 851-853

Mendelson BK, White DR, Mendelson MJ (1996): Self-esteem and body esteem: Effects of gender, age and weight. *Journal of Applied Developmental Psychology.* **17,** 321-346

Miller JZ, Kimes T, Hui S, Andon MB, Johnston CC (1991): Nutrient intake variability in a paediatric population: implications for study design. *Journal of Nutrition.* **121,** 265-274

Molloy AM, Scott JM (1997): Microbiological assay for serum, plasma, and red cell folate using cyropreserved, microtiter plate method. *Methods in Enzymology.* **281,** 43-53

Moore DC (1990): Body image and eating behaviour in adolescent boys. *American Journal of Diseases in Childhood.* **144,** 475-479

Morris A, Cooper T, Cooper PJ (1989): The changing shape of female fashion models. *International Journal of Eating Disorders.* **8,** 593-596

Moynihan P (2000): The British Nutrition Foundation Oral Task Force Report - issues relevant to dental health professionals. *British Dental Journal.* **188,** 308-312

Munoz KA, Krebs-Smith SM, Ballard-Barbash R, Cleveland LE (1997): Food intakes of US children and adolescents compared with recommendations. *Pediatrics.* **100,** 323-329

Must A, Dallal GE, Dietz WH (1991): Reference data for obesity: 85^{th} and 95^{th} percentiles of body mass index (wt/ht^2) and triceps skinfold thickness. *American Journal of Clinical Nutrition.* **53,** 839-846

Must A, Dallal GE, Dietz WH (1991): Reference data for obesity: 85^{th} and 95^{th} percentiles of body mass index (wt/ht^2) - a correction. *American Journal of Clinical Nutrition.* **54,** 773 (rapid communication).

Must A, Jacques PF, Dallal GE, Bajema CJ, Dietz WH (1992): Long-term morbidity and mortality of overweight adolescents. A follow-up of the Harvard Growth Study of 1922 to 1935. *New England Journal of Medicine.* **327,** 1350-1355

National Research Council (1980): Recommended Dietary Allowances, 9^{th} rev. ed. Committee on Dietary Allowances, Food and Nutrition Board, Division of Biological Sciences, Assembly of Life Science. Washington D.C: National Academy of Sciences

Nelson M, White J, Rhodes C (1993): Haemoglobin, ferritin, and iron intakes in British children aged 12-14 years: a preliminary investigation. *British Journal of Nutrition.* **70,** 147-155

Nelson M, Bakaliou F, Trivedi A (1994): Iron-deficiency anaemia and physical performance in adolescent girls from different ethnic backgrounds. *British Journal of Nutrition.* **72,** 427-433

Neumark-Sztainer D, Story M, Perry C, Casey MA (1999): factors influencing food choices of adolescents: Findings from focus-group discussions with adolescents. *Journal of the American Dietetic Association.* **99,** 929-934, 937

Neumark-Stzainer D, Hannan, PJ (2000): Weight-related behaviours among adolescent girls and boys: Results from a national survey. *Archives of Pediatric and Adolescent Medicine.* **154,** 569-577

Northrop-Clewes CA, Paracha PI, McLoone UJ, Thurnham DI (1996): Effect of improved vitamin A status on response to iron supplementation in Pakistani infants. *American Journal of Clinical Nutrition.* **64,** 694-699

Nowak M, Speare R, Crawford D (1996): Gender differences in adolescent weight and shape-related beliefs and behaviours. *Journal of Paediatric and Childhood Health.* **32,** 148-152

Nowak M (1998): The weight-conscious adolescent: Body image, food intake, and weight-related behaviour. *Journal of Adolescent Health.* **23(6),** 389-398

Nutrition Advisory Group (1995): *Recommendations for a Food and Nutrition Policy for Ireland. Government Publications*, Dublin.

Nylander I (1971): The feeling of being fat and dieting in a school population. *Acta socio-medica Scandinavica.* **1,** 17-26

O'Brien MM, Kiely M, Harrington KE, Robson PJ, Strainn JJ, Flynn A (2001): The North/South Ireland Food Consumption Survey: vitamin intakes in 18-64-year old adults. *Public Health Nutrition.* **4(5A),** 1069-80

O'Loughlin J, Paradis G, Meshefedjian G, Gray-Donald K (2000): A five-year trend of increasing obesity among elementary schoolchildren in multiethnic, low-income, inner-city neighbourhoods in Montreal, Canada. *International Journal of Obesity.* **24,** 1176-1182

Olmedilla B, Granado F (2000): Growth and micronutrient needs of adolescents. *European Journal of Clinical Nutrition.* **54, Suppl 1,** S11-S15

Parsons TJ, Power C, Logan S, Summerbell CD (1999): Childhood predictors of adult obesity: a systematic review. *International Journal of Obesity.* **23,** Suppl 8, S1-S107

Pate RR, Pratt M, Blair SN, Haskell WL, Macera CA, Bouchard C, Buchner D, Ettinger W, Heath GW, King AC, Kriska A, Leon AS, Marcus BH, Morris J, Pafenbarger RS, Patrick K, Pollock ML, Rippe JM, Sallis J, Wilmore JH (1995): Physical activity and public health: a recommendation from the Centres for Disease Control and Prevention and the American College of Sports Medicine. *Journal of the American Medical Association.* **273,** 402-407

Patton GC, Szmukler GI (1995): Epidemiology of eating disorders. In: A. Jablensky (Ed.), *Epidemiological Psychiatry.* Balliere Tindall: London, 307-328

Patton GC, Carlin JB, Shao Q, Hibbert ME, Rosier M, Selzer R, Bowes G (1997): Adolescent dieting: healthy weight control or borderline eating disorder? *Journal of Child Psychology and Psychiatry.* **38(3),** 299-306

Patton GC, Selzer R, Coffey C, Carlin JB, Wolfe R (1999): Onset of adolescent eating disorders: population based cohort study over three years. *British Medical Journal.* **318**, 765-768

Pi-Sunyer FX (1991): Health implications of obesity. *American Journal of Clinical Nutrition.* **53,** 1595S-1603S

Pollitt E (1990): *Malnutrition in the Classroom.* Paris: UNESCO

Power C, Lake JK, Cole TJ (1997): Measurement and long-term health risks of child and adolescent fatness. *International Journal of Obesity.* **21**, 507-526

Power C, Lake JK, Cole TJ (1997*b*): Body mass index and height from childhood to adulthood in the 1958 British birth cohort. *American Journal of Clinical Nutrition.* **66,** 1094-1101

Prattala O (1988): Sociodemographic difference in fat and sugar consumption patterns among Finnish adolescents. *Ecology of Food and Nutrition.* **22,** 53-54

Prentice AM (1997): Obesity - the inevitable penalty of civilisation? *British Medical Bullitin.* **53**, 229-237

Provan D, Weatherall D (2000): Red cells II: acquired anaemias and polycythaemia. *The Lancet.* **355,** 1260-1268

Pugliese M, Lifshitz F, Grad G, Fort P, Marks-Katz M (1983): Fear of obesity. *New England Journal of Medicine.* **309,** 513-518

Reilly JJ, Dorosty AR, Emmett PM, The ALSPAC Study Team (2000): Identification of the obese child: adequacy of the body mass index for clinical practice and epidemiology. *International Journal of Obesity.* **24,** 1623-1627

Ricciardelli LA, McCabe MP (2001): Children's body image concerns and eating disturbance: a review of the literature. *Clinical Psychology Review.* **21(3),** 325-344

Richards MH, Casper RC, Larson R (1990): Weight and eating concerns among pre- and young adolescent boys and girls. *Journal of Adolescent Health Care.* **11,** 203-209

Robson PJ, Strain JJ, Cran GW, Savage JM, Primrose ED, Boreham CAG (1991): Snack energy and nutrient intakes of Northern Ireland adolescents. *Proceedings of the Nutrition Society.* **50,** 180A

Roche AF, Tyleshevski F, Rogers E (1983): Non-invasive measurement of physical maturity in children. *Research Quarterly for Sport and Exercise.* **54,** 364-371

Rogol AD, Clark PA Roemmich JN (2000): Growth and pubertal development in children and adolescents: effects of diet and physical activity. *American Journal of Clinical Nutrition.* **72(suppl),** 521S-528S

Rolland-Cachera M-F, Deheeger M, Bellisle F, Sempe M, Guilloud-Batouille M, Patois E (1984): Adiposity rebound in children: a simple indicator for predicting obesity. *American Journal of Clinical Nutrition.* **39,** 129-135

Rolland-Cachera M-F, Deheeger M, Guilloud-Bataille M, Avons P, Patois E, Sempe M (1987): Tracking the development of adiposity from one month of age to adulthood. *Annals of Human Biology.* **14,** 219-229

Rolland-Cachera M-F, Bellisle F, Deheeger M (2000): Nutritional status and food intake in adolescents living in Western Europe. *European Journal of Clinical Nutrition.* **54,** Suppl 1, S41-S46

Rolls (1988): Food beliefs and food choices in adolescents. *Medical Journal of Australia.* **148,** 9-13

Rosen JC, Gross J (1987): Prevalence of weight reducing and weight gaining in adolescent girls and boys. *Health Psychology.* **6(2),** 131-147

Rugg-Gunn AJ, Adamson AJ, Appleton DR, Butler TJ, Hackett AF (1993): Sugars consumption by 379 11-12-year-old English children in 1990 compared with results in 1980. *Journal of Human Nutrition and Dietetics.* **6,** 419-431

Rugg-Gunn AJ (2001): Nutrition, diet and oral health. *Journal of the Royal College of Surgeons of Edinburgh.* **46,** 320-328

Ryan YM, Gibney MJ, Johnson H, Flynn MAT (1996): Meat avoidance, weight perceptions and nutrient intakes of Irish teenage girls. *Proceedings of the Nutrition Society.* **56,** 49A

Ryan YM, O'Donaghue M, Cantwell M, Johnson H, Flynn MAT (1997): Milk avoidance and dietary calcium intakes of Irish teenage girls. *Proceedings of the Nutrition Society.* **56,** 50A

Ryan YM, Gibney MJ, Flynn MAT (1998): The pursuit of thinness: a study of Dublin schoolgirls aged 15y. *International Journal of Obesity.* **22,** 485-487

Sargent JD, Blanchflower DG (1994): Obesity and stature in adolescence and earnings in young adulthood. Analysis of a British birth cohort. *Archives of Pediatric and Adolescent Medicine.* **148,** 681-687

Schoenthaler SJ, Amos SP, Eyseck HJ, Peritz E, Yudkin J (1991): Controlled trail of vitamin-mineral supplementation: effects on intelligence and performance. *Personaltiy and Individual Differences.* **12,** 351-362

Scott JM, Weir DG, Kirke PN (1994): Prevention of neural tube defects with folic acid a success but… *Q Journal of Medicine.* **87,** 705-7

Scott JM (1999): Folate and vitamin B12. *Proceedings of the Nutrition Society.* **58,** 441-448

Seidell JC. (1999): Obesity: a growing problem. *Acta. Pediatrics.* **Suppl 428,** 46-50

Shapiro S, Newcomb M, Burns Loeb T (1997): Fear of fat, disregulated-restrained eating, and body-esteem: prevalence and gender differences among eight-to-ten-year-old children. *Journal of Clinical Child Psychology.* **26(4),** 358-365

Siegel JM, Yancey AK, Aneshensel CS, Schuler R (1999): Body image, perceived pubertal timing, and adolescent mental health. *Journal of Adolescent Health.* **25,** 155-165

Siervogel RM, Roche AF, Guo S, Mukherje ED, Chumlea WC (1991): Patterns of change in weight/stature^2 from 2 to 18 years: findings from long-term serial data for children in the Fels Longitudinal Growth Study. *International Journal of Obesity.* **15,** 479-485

Sothern MS, Loftin M, Suskind RM, Udall JN, Blecker U (1999): The health benefits of physical activity in children and adolescents: implications for chronic disease prevention. *European Journal of Paediatrics.* **158,** 271-4

Stafford M, Wells JC (1998): Television watching and fatness in children. *Journal of the American Medical Association.* **280(14),** 1231-1232

Stang J, Story MT, Harnack L, Neumark-Sztainer D (2000): Relationships between vitamin and mineral supplement use, dietary intake, and dietary adequacy among adolescents. *Journal of the American Dietetic Association.* **100,** 905-910

Stark O, Peckham CS, Moynihan C (1989): Weight and age at menarche. *Archives of Diseases in Childhood.* **64,** 383-387

Stice EM, Schipak-Neuberg E, Shaw HE, Stein RI (1994): Relation of media exposure to eating disorder symptomatolgy: an examination of mediating mechanisms. *Journal of Abnormal Psychology.* **103,** 836-844

Story M, French S, Resnick M, Blum R (1995): Ethnic/racial and socioeconomic differences in dieting behaviours and body image perceptions in adolescents. *International Journal of Obesity.* **18,** 173-179

Taras HL, Sallis JF, Patterson TL, Nader PR, Nelson JA (1989): Television's influence on children's diet and physical activity. *Development and Behaviour in Pediatrics.* **10,** 176-180

Taylor LW, Jones IE, Williams SM, Goulding AE (2000): Evaluation of waist circumference, wasit-to-hip ratio and the conicity index as screening tools for high trunk fat mass, as measured by dual-energy X-ray absorptiometry in children aged 3-19 years. *American Journal of Clinical Nutrition.* **72,** 490-495

Thomas J (1991): Food choices and preferences of schoolchildren. *Proceedings of the Nutrition Society.* **50,** 49-57

Thomsen K, Riis B, Krabbe S, Christiansen C (1986): Testosterone regulates the haemoglobin concentration in male puberty. *Acta Paediatric Scandinavica.* **75,** 793-796

Tomeo CA, Field AE, Berkey CS, Colditz GA, Frazier AL (1999): Weight concerns, weight control behaviours, and smoking initiation. *Pediatrics.* **104,** 918-924

Torun B, Davies SW, Livingstone MBE, Paolisso M, Sackett R, Spurr GB (1996): Energy requirements and dietary energy recommendations for children and adolescents 1 to 18 years old. *European Journal of Clinical Nutrition.* **50,** Suppl.1, S37-S81

Troiano RP, Flegal KM, Kuczmarski RJ, Campbell SM, Johnson CL (1995): Overweight prevalence and trends for children and adolescents. The National Health and Nutrition Examination Surveys, 1963 to 1991. *Archives of Pediatric and Adolescent Medicine.* **149,** 1085-1091

Vander Wal JS, Thelen MH (2000): Eating and body image concerns among obese and average-weight children. *Addictive Behaviours.* **25(5),** 775-778

Van Lenthe FJ, Kemper HCG, van Mechelen W (1996): Rapid maturation in adolescence results in greater obesity in adulthood: The Amsterdam Growth and Health Study. *American Journal of Clinical Nutrition.* **64,** 18-24

Wadden TA, Foster GD, Stunkard AJ, Linowitz JR (1989): Dissatisfaction with weight and figure in obese girls: discontent but not depression. *International Journal of Obesity.* **13,** 89-97

Wahl R (1999): Nutrition in the adolescent. *Pediatric Annals.* **28,** 107-111

Wald NJ, Watt HC, Law MR, Weir DG, McPartlin J, Scott JM (1998): Homocysteine and ischaemic heart disease. *Archives of Internal Medicine.* **158,** 862-867

Wardle J, Marsland L (1990): Adolescent concerns about weight and eating; a social-developmental perspective. *Journal of Psychosomatic Research.* **34(4),** 377-391

Wardle J, Volz C, Golding C (1995): Social variation in attitudes to obesity in children. *International Journal of Obesity.* **19,** 562-569

Wattigney WA, Webber LS, Srinivasan SR, Berenson GS (1995): The emergence of clinically abnormal levels of cardiovascular disease risk factor variables among young adults: the Bogalusa Heart Study. *Preventive Medicine.* **24,** 617-626

Weaver C (2000): The growing years and prevention of osteoporosis in later life. *Proceedings of the Nutrition Society.* **59,** 303-306

Webber LS, Srinivasan SR, Wattigney WA, Berenson GS (1991): Tracking of serum lipids and lipoproteins from childhood to adulthood: The Bogalusa Heart Study. *American Journal of Epidemiology.* **133,** 884-899

Wickramasinghe SN (1995): Morphology, biology and biochemistry of cobalamin and folate deficient bone marrow cells. *Baillieres Clinical Haematology.* **8,** 441-459

Wissler RW (1991): USA multicenter study of the pathobiology of atherosclerosis in youth. *Annals of the New York Academy of Science.* **623,** 26-39

Wood KC, Becker JA, Thompson JK (1996): Body image dissatisfaction in preadolescent children. *Journal of Applied Developmental Psychology.* **17,** 85-100

World Health Organisation (1995): *Physical status: the use and interpretation of anthropometry.* Geneva: WHO, 1995

World Health Organisation (1996): *Preparations and use of food-based dietary guidelines.* Geneva: WHO, NUT/96.6

WHO, UNICEF & IVACG (1997): Vitamin A supplements: a guide to their use in the treatment and prevention of VAD and VAD xeropthalmia. 2^{nd} edn. Geneva: WHO

World Health Organisation (1998): *Obesity: preventing and managing the global epidemic.* Report of a WHO consultation, Geneva, 3-5 Jun 1997. Geneva: WHO (WHO/NUT/98.1)

Zwiauez KF, Pakosta R, Mueller T, Wildham K (1992): Cardiovascular risk factors in obese children in relation to weight and body fat distribution. *Journal of the American College of Nutrition.* **11,** 41-50

Chapter 2

Methods

2.1 Study design.

Ethical approval for this research was obtained from the Joint Research Ethics Committee of Saint James's Hospital and the Federated Dublin Voluntary Hospitals. To achieve ethical approval it was necessary to provide a protocol of the study, the letter of recruitment and the name of a nominated medical representative with whom the protocol was discussed. Data was collected from children attending 5^{th} and 6^{th} classes (age 10-12 years) in a total of fifteen fee-paying (FP; *n* 7) and non-fee-paying (NFP; *n* 8) primary schools from inner city Dublin in an effort to ensure that all socio-economic classes (SEC) would be represented. The study was cross-sectional in design and was conducted during consecutive school years 1998-1999 and 1999-2000 comprising of two separate parts. The first part of the study provided baseline information about the body image concerns of a representative sample of Dublin schoolchildren. Information on anthropometry, dietary intake, iron and folate status, physical and sedentary activities was collected from a random sample of the children involved in the initial recruitment. In addition, an assessment of the prevalence of dental caries took place among a smaller cohort. One year later, the second part of the study examined the same factors (except the dental aspect) in the same random sample as a one-year follow-up (figure 1).

2.2 Subjects recruitment.

In part one of the study, twenty-one inner city Dublin schools were approached to take part in the study. The selection of schools was made from lists of Dublin city primary schools provided by the Department of Education and by Community Care Areas 1 and 2 (that cover inner city Dublin) of the Eastern Health Board. Schools that provided for special needs or those conducted through the Irish language were excluded. A detailed letter describing the background to and the protocol of the study (appendix A.1) was sent to the principal of each school and was followed up by a telephone call one week later. Seventy-one percent (*n* 15) of the schools invited agreed to participate in the study including 7 fee-paying (FP; 6 single- and 1 mixed-sex) and 8 non-fee-paying (NFP; 4 single- and 4 mixed-sex) schools. It was hoped to give an equal representation of single- and mixed-sex schools but within the Irish school system FP schools tend to only be single-sex schools. Reasons for not taking part in the study included expected school inspections by the Board of Education (5%, *n* 1), concern that the study would take up too much class time (19%, *n* 4) and a lack of interest from parents when approached about the study (5%, *n* 1).

A detailed letter describing the study with a "tear-off" consent form (appendix A.2) was sent to the parents of 789 children in 5th and 6th classes (aged 10-12 years). Sixty percent (*n* 476) of the invited children obtained parental consent and agreed to take part with the acceptance rates among the FP schools ranging from 40-82% and among the NFP schools from 46-86%. Of these one child had coeliac disease and was excluded. Due to absenteeism on the initial day of the study, data was collected from a final sample of 434 children (184 boys, 250 girls, 213 FP, 221 NFP, mean age 11 years) or 91% of those who accepted. The response rate (the number of children from which data was initially collect) ranged from 40-72% among FP schools and 34-84% among the NFP schools. If a subject was not present on the initial day they were excluded from the study regardless of consent to take part. A random sample of 251 children (119 boys, 132 girls; 113 FP, 138 NFP) or 58% of those children that responded continued with part 1 of the study and the information collected from the remaining sample (n 183; 65 boys, 118 girls, 100 FP and 83 NFP) was excluded from analysis. If a child was absent their position was filled from one of those children not included in the original random sample but who was present on the initial day.

Eighty-two percent (*n* 207) of this random sample participated in part 2 of the study (school year 1999-2000). At this stage, 55% (*n* 132) of the random sample had progressed to secondary school increasing the number of schools involved to 31. Of these children, 87% (*n* 115) continued with the study. Reasons for discontinuance included the secondary schools refusal to take part in the study (1%, *n* 3), parental consent denied (5%, *n* 12), or the child had moved outside the Dublin area (1%, *n* 2). In addition, one of the original FP schools opted to discontinue with the study because of a busy school schedule thus decreasing the number of subjects by 11% (*n* 27). In both parts, the proportion of boys and girls attending FP and NFP schools was comparable.

A sixty percent (n476 of 789 invited) response rate is felt to represent children attending 5^{th} and 6^{th} classes at schools in inner city Dublin, although not all of these children participated in the full study. Those that did participate in the full study were randomly selected from respondents and therefore, are still thought to represent inner city Dublin schoolchildren. The response rate reported in this study is comparable to that of other Irish (Ryan *et al* 1998) and British studies (Nelson *et al* 1993). However, it is acknowledged that those who refused to participate in the study may represent a group with particular nutritional concerns.

2.3 Data collection.

Data collection for part 1 of the study began in December 1998 (school year 1998-1999) with a self-administered questionnaire (appendix A.3). Data collection of part 1, involving the random sample only, continued after the Christmas holidays from January to May 1999. In order to minimise disruption in individual schools and to eliminate seasonal bias, schools were visited in rotation on a three-weekly basis.

Data collection of part 2 of the study commenced with a self-report questionnaire (appendix A.3) during December 1999 (school year 1999-2000) and continued in January to May 2000. The same timetable incorporated in part one was applied to part two, accommodating the secondary schools as follows: children who were now attending post-primary (secondary) school were visited on the same day their primary school was attended by the investigator. The proportion of children who provided adequate information for analysis of fear of fatness, body weight status, nutrient intake and sample of blood for tissue store determination is shown in table 1 according to sex and year of study.

2.3.1 An overview of the timetable.

The investigator met with the children, on average, a total of four occasions at each part (1 and 2) of the study. Each meeting took approximately 20-30 minutes. On the initial day, the children, as a group at each school, completed a self-report questionnaire

At the second and subsequent meetings, the investigator (AG) met with the children in pairs within each school. Usually, no more than a group of 10 children was seen within a school on a given day to minimise disruption to classes. At the second meeting, the children completed an interview-assisted questionnaire (appendix A.4), had measures of anthropometry taken and were given their first food diary (appendix A.7) to record.

At the third meeting the children returned their food diaries and two finger-prick blood samples were taken. If the food diary was not returned the child was asked to bring it to school for collection the next day.

At the fourth meeting (three weeks after the third), the second food diary was collected and another measure of anthropometry was taken. During the month of March 1999, a dentist from the Dublin Dental hospital visited each school and assessed the prevalence of dental caries. The format of part two followed exactly that of part one with the one exception that dental caries was not measured.

2.4 Self-report questionnaire.

The questionnaires for this study were developed following guidelines (Stone 1993) that aim to limit biased responses: each part of the questionnaire consisted of a number of both open-ended and closed questions; response options including (where necessary) a "don't know" option, instructions (such as "tick or circle the appropriate answer"), and examples were provided where appropriate. The validity of any questionnaire needs to be specific to the intended purpose and audience (Contento I *et al* 2002). Therefore, a standard script was developed to further focus each question and ensure complete understanding of what information was sought from the subjects. The questionnaire (appendix A.3) consisted of four parts. Every question was answerable so that no one child would feel individualised by having nothing to write and would therefore not feel influenced or biased to an answer completely at random. Before commencing data collection and throughout the study, the children were repeatedly reassured of the confidentiality of all information collected. The importance of accurate and honest responses was emphasised and re-emphasised throughout the data collection period.

Before pilot testing reasonable confidence in the validity of the figure line drawings was taken from the frequency of their use in studies assessing body image concerns (discussed in section 1.2.1). Furthermore, the set of drawings applied in the current study were taken from a study of body figure perceptions and preferences among 1118 preadolescent children (Collins 1991). The figure line drawings were reviewed by child and adult jurors, pilot-tested, and examined for test-retest reliability and criterion validity in their development (Collins 1991).

2.4.1 Pilot test

Before commencing data collection, the questionnaire was pre-tested in an effort to ensure that its content was both unambiguous and comprehensible to the target population and reliable. A sample group of 34 schoolchildren (17 boys, 17 girls; mean age 10.4 years) in fifth class of a mixed non-fee paying school took approximately 20 minutes to complete the questionnaire. Their teacher was also present in the room and was asked her opinion on the language used in the questionnaire (i.e. her opinion of its comprehension by this age group). The questionnaire was administered in an "exam-type" classroom setting.

Exactly one week later the questionnaire was administered to the same sample group. Seven subjects (2 girls and 5 boys) were absent on the second occasion. The subjects had no prior knowledge that they would be receiving the questionnaire a second time. The reproducibility of each question was calculated as the proportion of the total number of subjects who gave the same answer to the question being asked on the two separate occasions. The higher the proportion the more reliable the question was at obtaining the information being sought. Overall, the reproducibility of this questionnaire was acceptable. The scores for each part were as follows: Part A (age), 100%; Part B (inactivity frequency and duration), 67-77%; Part C (dental health and nutritional knowledge), 67-100%; Part D (body image concerns and slimming practices), 63-100%. Or in other words, approximately 72% gave consistent answers in part B, approximately 84% to part C and approximately 82% to part D. In the initial draft the question "have you ever tried to change the shape of your body?" was phrased as "have you ever tried to change the way you look?" but to avoid confusion with fashion looks (e.g. clothes, hairstyle etc.) it was changed for the final draft.

2.4.2 Administering the questionnaire.

There were two questionnaires: a blue-covered one for boys and a pink-covered one for girls. The only difference between the two was in the section on body image concerns and slimming practices where the boys' questionnaire had the relevant figure line drawings of boys and the girls' questionnaire had the relevant pictures of girls (drawings adapted from Collins 1991). This avoided unnecessary confusion when it came to circling the figures according to the question that was asked.

The questionnaire took approximately 20 minutes to complete. The interviewer used an overhead projector to accompany the questionnaire. Each question that was to be answered on the questionnaire was represented on acetates. The advantage to this was that every child answered the same question at the same time and that the investigator read each question so the risk of misinterpreting what was asked was minimised. The children were given time to answer each question before moving onto the next. A teacher was usually present in the room.

2.4.3 Questionnaire content.

Part A was designed to determine demographic details (age, date of birth and sex).

Part B was designed to evaluate the frequency and duration during a typical week of time spent at sedentary activity. The answers were scattered on the page beneath each question so that they were not immediately obvious as a scale. The subject actually had to take time and read each answer and decide upon his/her answer i.e. could not continuously pick, for example, the third answer from the scale for each question.

Part C concerned dental health. Dental hygiene practices were evaluated by assessing the frequency of toothbrushing and dental visits. Again, these scaled responses were scattered on the page beneath the questions for the same reasons as outlined above. Adverse dental experiences, including tooth extraction, tooth abscess, fillings, and toothache were assessed by questions where "yes", "no", and "don't know" options were provided. Providing statements that required "true", "false" and "don't know" replies assessed dental and nutritional health knowledge with specific regard to sugar. These statements indicated the subjects' actual nutritional knowledge and attitude towards sugar.

Finally in this section the subjects were asked what they thought of their own diets in terms of whether they perceived their own diet as healthy, unhealthy or both and whether they had ever tried to change their diets. They were then asked to identify their sources of healthy eating information as these influence their food choice. As well as a list of possible sources of nutritional information (parents/guardians, friends, magazines, shops/supermarket, TV/radio, doctor, teacher) space was provided in which the subject could write additional sources he/she would resort to that were not included in the list. Lastly, they were asked in an open-ended question what they would spend £1 on? The question aimed to achieve an indication of the spending choice of children aged 10-12 years from socially diverse backgrounds e.g. would they spend it on sweets, magazines, stickers etc. or would they save it?

Part D assessed the subjects body image concerns and slimming practices. They were first asked if they would like to be taller, smaller, or the same height, and secondly if they would like to be heavier, lighter or the same weight (they ticked a box next to their choice of answer). Next they were asked if they had ever tried to change the shape of their body.

To establish the prevalence of inappropriate dieting practices in this age group (10-12 years) the subjects were asked if they ever tried to either put on weight or to lose weight with "yes", "no" and "don't know" options. A list of possible methods for putting on weight and for losing weight was provided to assess common slimming practices among this age group. Again additional space was provided for the subject to include any other method he/she may have used to achieve their particular aim (i.e. either put on or lose weight).

Finally the subjects were presented with separate sets of figure line drawings of both girls and boys, women and men taken from Collins (1991). The questions asked regarding these drawings included "which one looks most like you?" The subject had to choose from the range of figure line drawings of both girls and boys (ranging from severely underweight, underweight, slightly underweight, normal weight, slightly overweight, overweight, to severely overweight) and circle the drawing they considered represented their body shape best. They were then asked which drawing they considered represented what shape they "would most like to look like?", "which one they felt the opposite sex was most attracted to?" and "which shape of the opposite sex they preferred the most?". Lastly they were asked to choose from the figure line drawings of grown women and men who they considered represented what they "will look like when they grow up?" and which they would "like to look like when they grow up?" Separate drawings, as described above, were presented for each question. The children were repeatedly reminded to ignore the outfits and hairstyles depicted by the figure line drawings and to concentrate on only the shape of their bodies.

Circling an identical figure for preferred body shape ("Which shape would you like to look like?") as that chosen for perceived body shape ("Which one looks like you?") indicated satisfaction with body shape. Circling a thinner or fatter figure for preferred body shape than that chosen for perceived body shape indicated dissatisfaction with a preference towards being thinner or heavier respectively. Disparity of self-perceived body shape was identified by the circling of a perceived figure that was thinner or fatter than the child's own shape as identified by actual relative weight (section 2.6.3).

2.5 Interview-assisted questionnaire.

2.5.1 Pilot testing.

Prior to data collection, the interview-assisted questionnaire was pre-tested among a representative group of 41 children attending a NFP school (20 boys and 21 girls, mean age 10.2 years). The primary aim of the pilot study was to identify at an early stage any problems with comprehension or bias. The investigator read each question and optional answers to the child. If the child expressed any confusion the question was clarified. It was found that the questionnaire was clearly understood by all the children. However, in some cases (8%, *n* 2), the child could not name the nutritional supplement they were given. It was decided to repeat the question in the food diary (described 2.8.2).

2.5.2 Administering the interview-assisted questionnaire.

This questionnaire (see appendix A.4) was completed at the second meeting with the investigator. The investigator read aloud the question and the optional answers to that question. Response options (including "don't know") were provided for each question. The child chose an answer that represented habitual practice and this was "ticked" by the investigator.

2.5.3 Questionnaire content.

Part A recorded demographic details including age (at last birthday), date of birth and gender. Asking the child if their parents worked and what each parent did for a living determined socio-economic status.

Part B assessed nutritional supplement use. If they answered "no" or "don't know" the investigator proceeded to part C. If the child answered "yes", they were then asked to name the supplement and how often they took it. If the subject could not remember the name they were asked to find out this information at home and record it in their food diary. The subject was also asked if they had ever attended a dietitian before and whether they had any "allergies" to food.

In part C physical activity was evaluated as the frequency and duration that children engaged in vigorous exercise which made them "feel out of breath or sweaty?" The type of exercise (e.g. football, hockey, running, etc.) was also recorded.

Part D included questions querying pocket money (money given to the child by parents/guardian for their own use). Receiving pocket-money, how often they received the pocket money, how much pocket money they received and options, from a given list of items to spend pocket money on, was recorded.

Part E was designed to elicit information on smoking habits and alcoholic consumption. The subjects were asked if they had ever smoked or taken alcohol? If they answered "no" or "don't know" the investigator proceeded to Part F. If they answered "yes" further questions to determine frequency of smoking and/or drinking alcohol were asked. They were also asked how many cigarettes they smoked or what and how much alcohol they drank?

Part F was designed to establish the prevalence and amount of parental control over snacking in the home. The subjects were asked if they had to ask permission before they took a snack at home and whether they were ever denied this. They were then asked (in an open-ended question) why they would not be allowed a snack and which particular foods,from a provided list, if any are forbidden as a snack.

Part G concerned the girls only as it questioned the commencement ("have you had your period yet?") and age of first menstruation.

2.5.4 Socio-economic class.

Social class was classified according to the highest classed earner (usually a parent or guardian) within a household (O'Hare 1982). For statistical analysis social classes one and two, three and four, and five and six were combined to form socio-economic classes one, two and three, respectively. Accordingly, among the total group (*n* 434), 50% (*n* 217) were of SEC 1, 22% (*n* 95) of SEC 2, and 28% (*n* 121) of SEC 3. These figures compare to those for social class groups from the census of 1996 (CSO 1998), which uses a similar classification system: 52% of SEC1, 33% of SEC 2 and 15% of SEC 3 (excluding those unclassified). Schooltype attended was also considered where fee-paying and non-fee-paying schools represented the advantaged and disadvantaged groups respectively.

2.6 Anthropometry

Measurements were made at the second and fourth meetings (figure 1) with the investigator. This allowed an assessment of weight gained or lost between food diary recordings. One trained investigator took all measurements to avoid inter-observer variation. All measurements were taken at baseline and at follow-up.

2.6.1 Height.

Height was measured to the nearest 0.1cm using a Leicester Height Measure (CMS Equipment). The subjects stood straight with their back to a straight stick (scaled for measuring height), their shoes removed and their heels together looking straight ahead. The point at which their height reached was read from the measure indicated by the calibrated headrest that defined an exact straight-line point. Girls with high ponytails or hair-bands were asked to remove those as they impeded the determination of this point.

2.6.2 Weight.

Weight was measured to the nearest 0.1kg using a mechanical Seca weighing scales that was serviced prior to the study. The subjects removed their shoes and school jumpers prior to being weighed.

2.6.3 Calculation of Actual Relative Weight.

Sex-specific growth standard charts for Irish males and females from birth to 19 years (Hoey et al 1986) were used to determine ideal weight for height, age and sex for each child. Actual relative weight was calculated as observed body weight expressed as a percentage of ideal body weight for height, age and sex (Roche 1984), as follows:

$$\text{Actual relative weight (\%)} = \frac{\text{Actual body weight (kg)}}{\text{Ideal body weight (kg)}} \times 100$$

Subjects were assigned to one of the following five categories of weight status defined by their actual relative weight (National Center for Health Statistics 1973): 1) underweight (<80%), 2) slightly underweight (80-89%), 3) normal weight (90-110%), 4) slightly overweight (111-120%), and 5) overweight (≥120%).

2.6.4 Body mass index.

Body mass index (BMI) was calculated from observed weight and height as follows:

$$\text{Body mass index (kg/m}^2\text{)} = \frac{\text{Weight (kg)}}{(\text{Height (m)})^2}$$

Body mass index was also used to calculate five categories of actual body weight using the Centre for Diseases Control BMI-for-age charts (Kuczmarski *et al* 2000; appendix

A.5) as follows: 1) underweight ($\leq 5^{th}$ percentile), 2) risk of underweight ($> 5^{th}$ and $\leq 10^{th}$ percentiles), 3) normal weight ($> 10^{th}$ and $\leq 85^{th}$ percentiles), 4) risk of overweight ($>85^{th}$ and $\leq 95^{th}$ percentiles), and 5) overweight ($> 95^{th}$ percentile).

Body mass index was also used to classify risk of overweight and overweight among the children according to the cut-offs identified by Himes and Dietz (1994) and the International Task Force on Obesity (Cole *et al* 2000). All cut-off values used to define risk of overweight and overweight are given in Chapter 3, Table 1.

2.6.5 Measurement of body fat.

All measurements were taken by the main investigator to avoid inter-observer variability. Three skinfold measurements were taken at each site and any measurements differing by more than 0.02mm were excluded to limit the effect of intra-observer variability. In addition, the accuracy of anthropometric measurements was validated by test-retest whereby the anthropometry was performed twice in a three-week period: at the distribution of the first food diary and at the collection of the second food diary. Measurements of body fat were taken using a Harpenden Skinfold Calliper (British Indicators Ltd.). This particular callipers was designed to exert a constant pressure of $0.098N/mm^2$ +/-10% at all openings (up to 40mm) of the $90mm^2$ anvils. Each small division on the dial was 0.2mm, but the instrument may be conveniently read to 0.1mm by interpolation between the markings.

All measurements were taken from the right hand side of the body. Three measurements were made at each site and the average reading was used in calculations. The mid-upper arm circumference was measured with the arm relaxed and hanging loosely by the subjects' side. The steel tape was passed around the arm at a right angle to the long axis of the arm so that it just touched the skin without compressing the tissue. The reading was taken to the nearest 0.1cm.

Triceps were measured at the mid-point of the back of the upper arm. The mid-point was determined with the arm flexed at 90° and as that point halfway between the tips of the acromial and olecranon processes. This point was marked with a biro. With the arm hanging freely by the side, the callipers were applied vertically above the olecranon at the marked level. A fold of skin and subcutaneous tissue was picked up between the thumb and forefinger of the left hand of the investigator. This fold was pinched clear away from the underlying muscle. It was held between the fingers (above the callipers) at all times the measurement was being taken. The fold was released between each separate measurement. In some subjects it proved difficult to accurately pull the skin and subcutaneous tissue from the underlying muscle in a clean pinch. These subjects were asked to clench their fists in an effort to assess the skinfold more easily. The subscapular skinfold was measured as the fold picked up just below the inferior angle of the scapula at 45° to the vertical along the natural cleavage lines of the skin. The subject stood relaxed with both arms by their sides (weiner and Lourie 1969; Durnin and Womersley 1974).

Further calculations were derived for mid-arm muscle circumference (MAMC) and mid-arm muscle area (AMA). The formulae for all calculations are contained in appendix A.6 (Durnin and Womersley 1974).

2.6.6 Body fat distribution.

Measurements were taken using a flexible 3 metre steel tape measure. The waist circumference was measured to the nearest centimetre at the minimum girth between the lower rib margin and the iliac crest over the naked site. The hip circumference was measured to the nearest centimetre at the level of the trochanters with the subject standing with feet together. The waist to hip ratio and the subscapular to triceps ratio (measurements described in 2.6.5) were computed as a measure of body fat distribution, where a high ratio indicates central fat patterning (Lohman *et al* 1988).

2.7 Pubertal stage of maturation.

Measurement of maturational stage among children involves invasive observations on the development of pubic hair and genitals in boys and of breasts and pubic hair in girls, and was not measured for this study. However, crude determination of early pubertal stage at age 12 years was determined using a height increment, over the year, of greater than or equal to 0.07m in boys and 0.06m in girls that typically represents height gain in the first year of the adolescent growth spurt (Tanner 1989). Menarche was used as a second index of a later maturational stage among girls that identified early maturers (Tanner 1989).

2.8 Dietary assessment.

Habitual dietary intakes were recorded in food diaries. The food diary was kept on two separate occasions for 48 hours (two days) on each occasion, which combined gave a total of four days dietary information. The two occasions were separated by three weeks. The method adopted in this study was designed to record dietary intakes in food diaries over a sufficiently short time (two days at a time) to dispel boredom and encourage memory recall at collection, but avoid introducing seasonal variation (three weeks separated the two recording occasions). Four days is deemed a sufficient amount of time to collect energy data in adults (Bingham 1987), but such evidence is lacking among children. It is acknowledged that, given the variability in intake of rich sources on a day-to-day basis, greater than 20 days is often required to collect valid estimates of micronutrient intakes among children (Miller *et al* 1991). Within each school type this was controlled to ensure there was no preponderance of one day over another and that one weekend day was always included. There were no verbal instructions at the second occasion from the investigator (the written instructions and the investigators contact number was included) when the food diaries were distributed to the subjects by their teachers. A leaflet was included which advertised the incentive (to win cinema tickets) for the subjects to adequately record and return their food diaries.

2.8.1 Pilot test.

Prior to the study the food diary was pilot tested among 41 non-fee-paying children attending single-sex schools (20 boys and 21 girls, mean age 10.2 (0.4) years). The primary aim of the pilot study was to identify at an early stage any problems of the methodology used which may effect all outcomes measured whether by inaccuracy, incomprehension or biases. The mean energy intake to estimated basal metabolic rate (section 2.8.6) was 1.57 (0.6) and the proportion of mis-reporters was comparable between the sexes. Thirty-four percent (n 14) and 10% (n 4) respectively under-reported and over-reported dietary intake.

2.8.2 The food diary.

The food diary was specifically designed for this study (appendix A.7) using a food diary from the North/South Ireland Food Consumption Survey as a template (Harrington *et al* 2001). One food diary was given to each subject at their first meeting with the investigator. It was lightweight and A5 size so that the subject could easily fold it up and carry it in their pocket. The first three pages of the food diary contained clear and precise instructions on how to record entries into the food diary. The contact telephone number of the investigator was also included in case the subject ran into any difficulties over the recording period of the following consecutive two days.

The investigator read through and explained each instruction with the subject. As an example of how to fill in the food diary the investigator asked the subject what he/she had eaten and drunk for breakfast on the morning before the meeting. This information was then recorded into the food diary in the presence of the subject as an example (page 4 of the diary) of how to complete the food diary. The subjects were also asked to try and collect all the wrappers or boxes of snack foods and drinks consumed by them over the recording period. This was not an obligatory requirement but simply an aid for the investigator in determining specific food/drink items e.g. determine whether "crisps" (as recorded in a food diary) were actually potato crisps or corn snacks. This request was poorly complied with only 3% (*n* 6) at baseline and a mere 2% (*n* 3) supplying packaging in the one-year follow-up.

The fifth and sixth pages were for the subject to fill in the name and type of milk they used at home (whether it was full fat or low-fat etc.), the name and type of spread and, if they took nutritional supplements, the name and the amount of nutritional supplement consumed. A letter directed to the parents/guardians of the subjects was also included (appendix A.8). This asked them to check over the food diary with their child and if possible to include recipes of any composite dish consumed over the two days. The parents/guardians were not under any obligation to comply with this. There was a back page included in the food diary for the parent/guardian to sign if they had complied.

2.8.3 Reporting daily food intake.

Briefly, the subjects were asked to record each separate eating occasion on a new page in the food diary (20 pages were included in the diary to cover the recording period of two days). An eating occasion was described as a food or drink consumed 20 minutes since a previous food or drink was consumed. For each eating occasion they had to record (besides the food/drink item(s)) the date (day and month), the present time of the day, their location while consuming the food/drink and whether they considered the food/drink as a meal or a snack.

They were also asked to describe the food/drink in as much detail as possible with the aid of headings provided in columns on the food diary page. These were "amount" (for example, bread would be described in number of slices), "food/drink" (i.e. the actual food/drink being consumed at the time), "description" (for, example whether bread was brown or white, buttered or dry, any other spreads etc.), "brand" (to identify the manufacturer of the food/drink for as accurate a post-analysis as possible), and "cooking method" (i.e. whether the food/drink had been fried, baked, grilled etc.). There were two further columns in which the investigator could record the food code (for nutritional analysis using M^{c}Cance and Widdowsons "Composition of Foods and Supplements", Fifth Edition, 1991) and the estimated weight of the food/drink.

2.8.4 Quantification of food and drink consumed.

The subjects were asked to keep their food diaries for the next two days and met with the investigator for the third and fourth meeting on day three. At this meeting the investigator worked through the food diary page by page with the subject in order to estimate the weights of the foods/drinks consumed. A food atlas and food "props" were used as visual aids. The food atlas was a combination of that used by the Irish National Nutrition Survey (Lee and Cunningham 1990) and by the Irish Universities Nutrition Alliance (Harrington *et al* 2001). It therefore had a number of photographs of different portion sizes for common foods. The "props" used included breakfast cereals, a measuring jug (which was used to establish how much milk was used on cereals, in tea/coffee etc.), a teaspoon, dessertspoon, soupspoon and tablespoon (as children of this age (10-12 years) may not necessarily comprehend the weight differences between each of these utensils) and a cup (200ml) and mug (300ml) (as there is also a distinct difference in the quantity each of these hold although they both commonly go under the general name of "cup"). For those foods that could not be identified in the food atlas and which the subject did not record or could not recall, the amount of recognised estimated average food portion sizes were used (Crawley, 1988).

Any subject who was absent or who forgot to return their food diary was followed up the next day. If the food diary had not been returned within four days of the collection period it was not included for nutrient analysis (5% (n 12) in 1998-1999 and 12% (n 22) in 1999-2000).

2.8.5 Nutrient analysis.

All food and drink items were coded for nutritional analysis by the WISP V1.26 nutritional package for Windows (Tinuviel Software). This package uses the food codes of M^{c}Cance and Widdowsons Composition of Foods (Fifth Edition, 1991) and Supplements (1988-1998; Holland *et al* 1995; Chan *et al* 1995; Chan *et al* 1996; Holland *et al* 1998; Holland *et al* 1989; Holland *et al* 1991; Holland *et al* 1992; Holland *et al* 1992; Holland *et al* 1993; Chan *et al* 1994). For those foods that were not included in the database the closest resembling food/drink was used (based on nutritional analysis per 100g). Mean daily intakes for macro- and micro- nutrients were computed by the nutritional package for each subject and transferred to SPSS for Windows for statistical analysis.

2.8.6 Identification of under- and over-reporting.

Basal metabolic rate (BMR_{est}) for boys and girls of a given age and weight were predicted from mathematical equations derived by Schofield (FAO/WHO/UNU 1985; Schofield 1985). To accept data as representative of habitual intake the ratio of mean energy intake to estimated basal metabolic rate ($EI:BMR_{est}$) to calculate estimates of physical activity levels was used (Torun *et al* 1996). Provisional "cut-off" values have been published to determine the acceptance of energy intake data: 6-18 years; 1.39-2.24 x BMR (boys) and 1.30-2.10 x BMR (girls) (Torun *et al* 1996). Children with estimated physical activities less than the sex-specific cut-off were identified as under-reporters. Children with estimated physical activity levels greater than the sex-specific cut-off were identified as over-reporters. Children whose estimated physical activity levels fell between the lower and upper sex-specific cut-offs were identified as adequate reporters of habitual energy intake.

2.9 Blood sampling

2.9.1 Overview

The main investigator carried out all blood analysis except for red cell folate determination, which was carried out by the Vitamin Research Laboratory at Trinity College, Dublin. Prior to data collection the method of capillary (finger-prick) blood sampling was learnt and practised by the investigator as described in "Practical Heamatology" (Dacie and Lewis 1995). The blood samples were collected at the second meeting with the investigator. The samples were used to determine the full blood count, serum ferritin and red cell folate concentrations. In addition, an evaluation of soluble serum transferrin receptor was estimated in part two of the study. Fasting was not required as serum ferritin, red cell folate and soluble serum transferrin receptor are all indicators of long-term stores and are not affected by recent food intake.

2.9.2 Collection of capillary blood samples.

Two finger-prick blood samples were taken from the children. The blood sample was taken from the index finger. The child firstly warmed their hands by placing them in warm water for approximately 5 minutes. The site was then dried and sterilised using an alcohol swab. The finger was pricked using a Unistix Lancet 0.3 mm (J.S. Dobbs & Co. Ltd.) and the first drop of blood was wiped away with a tissue as it would contain debris of the interstitial fluid following the initial assault of the puncture site. Slight pressure was applied to the childs finger by the investigator in order to encourage blood flow. The samples (approximately 0.75 to 1ml in total) were collected into EDTA microvette containers (red cap; Sarstedt Laboratories) for analysis of full blood count and red cell folate and serum microvette containers (white cap; Sarstedt Laboratories) for analysis of serum ferritin and soluble serum transferrin receptor.

All samples were transported within four hours of collection to the haematological laboratory in the Dublin Institute of Technology, Kevin Street, for analysis. The clotted samples were held at 37°C and the anti-coagulated samples at 4°C during transportation. Any samples found to have haemolysed were discarded and repeated during the third meeting with the investigator.

2.9.3 Pilot test of blood sampling.

The use of finger-prick blood samples was pre-tested in a previous study (Ryan YR, personal communication, 1998). In order to determine if the use of finger-prick blood samples produce erroneous results, a finger-prick and a venous blood sample was collected from a total of 8 healthy volunteers; a full blood count and measurement of serum ferritin and red cell folate concentrations was carried pout using both samples. Both samples were handled in exactly the same manner. Although slight differences were observed between the samples (table 2), none reached statistical significance or could be considered of clinical importance.

2.9.4 Full Blood Count.

The FBC includes measurement of white cell count (WBC), red cell count (RBC), haemoglobin (Hgb), haematocrit (HCT), mean corpuscular volume (MCV), mean corpuscular haemoglobin (MCH), mean corpuscular haemoglobin concentration (MCHC) and platelet (PLT) count. It was analysed using 50μLs sample of whole blood using a semi-automated haematology analyser – Cobas Micros (MSC Ltd., Roche). A tri-level haematology control representing low, normal and high concentrations of the above parameters (CBC-ST, R&D Systems Inc., Accu-Science Ireland Ltd.) designed to monitor values obtained from instruments was used before every batch of samples (usually a total of 10 per batch) was analysed. The results obtained were compared to the expected range of values provided. The Micros was serviced prior to and during the study period (MSC Ltd. Roche) to ensure that its capacity for accurate measurements was maintained.

2.9.5 Serum ferritin.

2.9.5.1 Preparation of samples.

Serum samples were centrifuged at 2,500rpm for 6 minutes and the resultant serum (approximately 50μL to 150μL) was stored in Micronic tubestrips (Sarstedt Ltd.) at –20°C for analysis at a later stage using the Enzymun-Test ferritin kit for ES systems (Boehringer Mannheim Immundiagnostics). The ferritin concentration was measured in a 30μL sample of serum.

2.9.5.2 Principle of assay.

The method used was an enzyme immunoassay one-step sandwich assay using streptavidin technology. Analysis is based on the formation of a "sandwich" between the analyte to be detected (ferritin) and two specific monoclonal antibodies directed to different epitopes on the ferritin molecule. The capture antibody is conjugated to biotin while the second antibody, used to reveal the reaction is labelled with POD peroxidase. The immunological reaction between the analyte and the monoclonal antibodies occurs in a homogenous phase in the presence of steptavidin immobilised on the solid phase, which allows bound/free separation. Measurement of the bound enzyme activity is performed by adding a chromogen/substrate solution. The enzyme action on the chromogen/substrate produces a colour that can be detected with a photometer.

2.9.5.3 Method and calculation of results.

Samples were thawed (only once) at 4°C. Solutions were prepared per manufacturers instructions (Enzymum-Test Ferritin Kit; Boehringer Mannheim Immunodiagnostics). Standards and control sera were run in duplicate. 30µL of each of the five standards (ferritin range 0-1100ng/ml), the control serum (Precinorm IM; Boehringer Mannheim Immunodiagnostics) and the samples were added into plastic tubes coated with streptavidin. 1.0ml of the incubating solution (anti-ferritin conjugate) was added to each tube. All tubes were mixed and incubated at room temperature for 30 minutes. The contents of the tubes were then discarded and washed well with distilled water. 1.0ml of the chromogen substrate solution was added to each tube, mixed and further incubated for 30 minutes at room temperature. The tubes were again mixed and read at 422nm using a spectrophotometer.

A standard curve was obtained by plotting the absorbance of the standards against their ferritin concentrations expressed in ng/ml. The ferritin concentration of the controls and samples was determined from the standard curve by interpolation. The value obtained for the control serum was compared with the expected range given.

2.9.6 Red cell folate.

2.9.6.1 Preparation of samples.

A 1 in 10 dilution of the remaining anti-coagulated sample (50μLs) was prepared in 1% ascorbic acid solution (450μLs) for analysis of red-cell folate. This was stored in Micronic tubestrips (Sarstedt Ltd.) at –20°C until analysis could be carried out using a microbiological assay. Analysis of red cell folate concentration was carried out by trained laboratory technicians at the Vitamin and Research Laboratory, Trinity College, Saint James's Hospital.

2.9.6.2 Principle of assay.

The diluted sample is added to the assay medium that contains all of the nutrients required for the growth of *Lactobacillus casei,* with the exception of folate. The growth response of the organism, estimated by measuring the turbidity of the medium, is proportional to the folate concentration of the sample (Molloy and Scott 1997).

2.9.7 Serum transferrin receptor.

2.9.7.1 Preparation of the samples.

Serum samples were centrifuged at 2,500rpm for 6 minutes and the resultant serum (approximately 50μL to 150μL) was stored in Micronic tubestrips (Sarstedt Ltd.) at –20°C for analysis at a later stage using the Quantikine® IVD® (R & D Systems, Inc.). The serum transferrin receptor concentration was measured in a 20μL sample of serum.

2.9.7.2 Principle of the assay.

The assay is based on the microplate sandwich enzyme immunoassay technique using two different monoclonal antibodies specific for serum transferrin receptors. Samples or standard are pipetted into wells of a microplate pre-coated with a monoclonal antibody that can capture serum transferrin receptors, thereby immobilising serum transferrin receptors to the well. After washing away any unbound protein, a second anti-serum transferrin receptor monoclonal antibody conjugated to horseradish peroxidase is added. The conjugated antibody completes the sandwich. After washing away unbound conjugated antibody, the amount of conjugate in the well is proportional to the amount of serum transferrin receptor initially captured. The amount of conjugated enzyme in the well is measured by incubation with a chromogenic sustrate.

2.9.7.3 Measurement and calculation of results.

All reagents were pre-prepared as per manufacturer instructions (R & D Systems). Standards and controls were analysed in duplicates. 100μL of serum transferrin receptor assay diluent was added to each microplate well. 20μL of each of the six standards (range 0-877ng/ml), sample and controls were added per well. The plate frame was gently tapped to mix the well contents, covered with an adhesive strip and left to incubate at room temperature for 1 hour. Each well was then aspirated and washed, the process repeated 3 times to give a total of four washes with liquid completely removed at each step. Any remaining wash buffer was removed by aspiration with a pipette. The plate was inverted and blotted against clean towel paper. 100μL of serum transferrin receptor conjugate was added to each well and the plate was covered with a new adhesive strip and incubated for 1 hour at room temperature. The aspiration and washing of the wells was repeated after this incubation. 100μL of substrate solution was added to each well and incubated for a further 30 minutes at room temperature. The plate was kept out of direct sunlight. 100μL of stop solution was added to each well and the plate was gently tapped to make sure that colour formation was evenly distributed throughout each well. The optical density of each well was read using a microplate reader (Labsystems Multiskan ® Plus) set to 450nm.

A curve was constructed by plotting the optical densities against the concentration of the standards. The serum transferrin receptor concentration of the controls and samples was determined from the standard curve by interpolation. The value obtained for the control serum was compared with the expected range given.

2.10 Statistical analysis.

Data was entered directly into SPSS for Windows, version 10.0 (Statistical package for the Social Sciences, SPSS Inc., Chicago) for statistical analysis. Details of specific statistical tests are given in each chapter.

Figure 1: An overview of the process of data collection from young adolescent Dublin schoolchildren participating in the current study.

December 1998

Self administered questionnaire in exam-type classroom setting

↓ *One month*

January to May1999

Distribution of first food diary, interview assisted questionnaire and anthropometry

↓ *Two days* → March 1999 Dental examination

Collection of first food diary and blood sampling

↓ *Two weeks*

Distribution of second food diary through the post

↓ *One week*

Collection of second food diary, and anthropometry measurements taken

↓

June to September 1999

Laboratory analysis of iron and folate clinical status

↓

December 1999

Self administered questionnaire in exam-type classroom setting

↓ *One month*

January to May2000

Distribution of first food diary, interview assisted questionnaire and anthropometry

↓ *Two davs*

Collection of first food diary and blood sampling

↓ *Two weeks*

Distribution of second food diary through the post

↓

Collection of second food diary, and anthropometry measurements taken

↓

June to September 2000

Laboratory analysis of iron and folate clinical status

Table 1: The proportion of Dublin adolescent schoolchildren who provided adequate information to allow analysis according to each chapter, year of study and sex.

Chapter	Title	Total group		Boys		Girls	
		1998-1999 (*n* 251)	1999-2000 (*n* 207)	1998-1999 (*n* 119)	1999-2000 (*n* 94)	1998-1999 (*n* 132)	1999-2000 (*n* 113)
		% (n)	% (n)	% (n)	% (n)	% (n)	% (n)
3	Indices of weight status, physical activity and body image concerns	100% (251)	96% (199)	100% (119)	96% (90)	100% (132)	83% (109)
4	Macronutrient intakes and associated body image concerns	95% (239)	89% (185)	92% (110)	84% (79)	98% (129)	94% (106)
5	Dietary factors and body image concerns associated with iron and folate status	95% (239)	89% (185)	92% (110)	84% (79)	98% (129)	94% (106)
6	Diet and dental health	52% (130)	na	48% (58)	na	55% (72)	na

na: not applicable

Table 2: A comparison of various haematological parameters in finger-prick and venous blood (*n* 8).

Haematological Parameter	Capillary blood Mean (SD)	Venous blood Mean (SD)	P value
Haemoglobin (g/dL)	14.0 (1.4)	13.7 (1.3)	0.1
Haematocrit (%)	41.0 (2.9)	39.2 (2.2)	0.1
Mean corpuscular volume (*f*L)	88.7 (2.7)	88.2 (4.8)	0.8
Mean corpuscular haemoglobin (pg)	30.4 (1.7)	30.7 (1.7)	0.2
Mean corpuscular haemoglobin concentration(g/dL)	34.3 (1.8)	34.8 (2.6)	0.5
Red blood cell (x 10^6/µL)	4.6 (0.3)	4.5 (0.3)	0.1
White blood cell (x 10^3/µL)	7.4 (1.1)	7.2 (1.2)	0.6
Platelets (x 10^3/µL)	263.6 (78.5)	284.8 (101.7)	0.5
Serum ferritin (ng/ml)	29.4 (25.8)	28.6 (26.1)	0.4*
Red cell folate (ng/ml)	244.9 (69.5)	219.4 (54.7)	0.2

P value for paired T-test or Wilcoxin test*

2.11 References:

Bingham SA (1987): The dietary assessment of individuals; methods, accuracy, new techniques and recommendations. *Nutrtiion Abstracts and Reviews.* **57(10),** 705-42

Central Statistics Office (1998): Principal socio-economic results 1998, volume **7,** 104-114. www.cso.ie

Chan W, Brown J, Lee SM, *et al* (1995): *Meat, Poultry and Game. Fifth Supplement to McCance and Widdowson's The Composition of Foods,* 5th ed. Royal Society of Chemistry and Ministry of Agriculture, Fisheries and Food. London: HMSO

Chan W, Brown J, Church SM, *et al* (1996): *Meat Products and Dishes. Sixth Supplement to McCance and Widdowson's The Composition of Foods,* 5th ed. Royal Society of Chemistry and Ministry of Agriculture, Fisheries and Food. London: HMSO

Chan W, Brown J, Buss DH (1994): *Miscellaneous Foods. Sixth Supplement to McCance and Widdowson's The Composition of Foods,* 5th ed. Royal Society of Chemistry and Ministry of Agriculture, Fisheries and Food. London: HMSO

Cole TJ, Bellizzi MC, Flegal KM, Dietz WH (2000): Establishing a standard definition for child overweight and obesity worldwide: international survey. *British Medical Journal.* **320**, 1240-1243

Collins ME (1991): Body figure perceptions and preferences among preadolescent children. *International Journal of Eating Disorders.* **10(2),** 199-208

Contento IR, Randell JS, Basch CE (2002): Review and analysis of evaluation measures used in nutrition education intervention research. *Journal of Nutrition Education and Behaviour.* **34**, 2-25

Crawley H (1988): Food portion sizes. *Ministry of Agriculture, Fisheries and Food.* HMSO

Dacie JV, Lewis SM (1995): *Practical Haematology.* Eight edition. Churchill Livingstone: New York

Durnin JVGA, Womersley J (1974): Body fat assessed from total body density and its estimation from skinfold thickness: measurements on 481 man and women aged 16-72 years. *British Journal of Nutrition.* **32,** 77-97

FAO/WHO/UNU (1985): *Energy and Protein requirements.* WHO Technical Report Series 724. World Health Organisation: Geneva

Harrington KE, Robson PJ, Kiely M, Livingstone MBE, Lambe J, Gibney MJ (2001): The North/South Ireland food consumption survey: survey design and methodology. *Public Health Nutrition.* **4 (5A),** 1037-1042

Himes JH, Dietz WH (1994): Guidelines for overweight in adolescence preventive services: recommendations from an expert committee. *American Journal of Clinical Nutrition.* **59,** 307-316

Hoey H, Tanner JM, Cox LA (1986): *Irish Clinical Growth Standards, Girls: Birth - 19 years, Height and Weight* and *Boys: Birth - 19 years, Height and Weight.* Castlemead Publications : Herts., Dublin, Ref. 312

Holland B, Unwin ID, Buss DH (1998): *Cereal and Cereal Products. Third Supplement to McCance and Widdowson's The Composition of Foods,* 4th ed. Royal Society of Chemistry and Ministry of Agriculture, Fisheries and Food. London: HMSO

Holland B, Welch AA, Unwin ID, Buss DH, Paul AA, Southgate DAT (1995): *McCance and Widdowson's The Composition of Foods,* 5th ed. Royal Society of Chemistry and Ministry of Agriculture, Fisheries and Food. London: HMSO

Holland B, Brown J, Buss DH (1993): *Fish and Fish Products. Third Supplement to McCance and Widdowson's The Composition of Foods,* 5th ed. Royal Society of Chemistry and Ministry of Agriculture, Fisheries and Food. London: HMSO

Holland B, Unwin ID, Buss DH (1992): *Fruit and Nuts. First Supplement to McCance and Widdowson's The Composition of Foods,* 5th ed. Royal Society of Chemistry and Ministry of Agriculture, Fisheries and Food. London: HMSO

Holland B, Welch AA, Buss DH (1992): *Vegetable Dishes. Second Supplement to McCance and Widdowson's The Composition of Foods,* 5th ed. Royal Society of Chemistry and Ministry of Agriculture, Fisheries and Food. London: HMSO

Holland B, Unwin ID, Buss DH (1991): *Vegetables, Herbs and Spices. Fifth Supplement to McCance and Widdowson's The Composition of Foods,* 4th ed. Royal Society of Chemistry and Ministry of Agriculture, Fisheries and Food. London: HMSO

Holland B, Unwin ID, Buss DH (1989): *Milk products and Eggs. Fourth Supplement to McCance and Widdowson's The Composition of Foods,* 4th ed. Royal Society of Chemistry and Ministry of Agriculture, Fisheries and Food. London: HMSO

Kuczmarski RJ, Ogden CL, Grummer-Strawn LM, Flegal KM, Guo SS, Wei R, Curtin LR, Roche AF, Johnson CL. (2000): CDC growth charts: United States. Advance data from vital and health statistics; no.314. Hyattsville, Maryland: National Center for Health Statistics http://www.cdc.gov/nchs/

Lee P, Cunningham K (1990): *The Irish National Nutrition Survey.* Dublin: Irish Nutrition and Dietetic Institute

Lohman TG, Roche AF, Martorell R (1988): *Anthropometry Standardisation Reference Manual,* eds. Lohman, roche and Martorell. Champaign IL: Human Kinetics

Miller JZ, Kimes T, Hui S, Andon MB, Johnston CC (1991): Nutrient intake variability in a pediatric population: implications for study design. *Journal of Nutrition.* **121,** 265-274

Molloy AM, Scott JM (1997): Microbiological assay for serum, plasma, and red cell folate using cryopreserved, microtitre plate method. *Methods in Enzymology.* **281,** 43-53

National Centre for Health Statistics (1973): *Height and Weight for Youths, 12 - 17 Years, United States.* US Department of Health: Bethesda, MD. Education and Welfare Series 11, No. 24

Nelson M, White J, Rhodes C (1993): Haemoglobin, ferritin, and iron intakes in British children aged 12-14 years: a preliminary investigation. *British Journal of Nutrition.* **70,** 147-155

O'Hare A. (1982): A note on a proposed census-based Irish social class scale for epidemiological health research. *Economic and Social Reviews.* **13(3),** 205

Roche AF (1984): Anthropometrical methods: new and old, what they tell us. *International Journal of Obesity.* **8,** 509-523

Ryan YM, Gibney MJ, Flynn MAT (1998): The pursuit of thinness: a study of Dublin schoolgirls aged 15y. *International Journal of Obesity.* **22,** 485-487

Schofield WN (1985): Predicting basal metabolic rate, new standards and review of previous work. *Human Nutrition and Dietetics.* **39C,** Suppl 1, 5-41

Stone DH (1993): Design a questionnaire. *British Medical Journal.* **307**, 1264-6

Tanner JM (1989): Puberty. In: *Foetus into man: Physical growth from conception to maturity.* (2nd ed.) Castlemead Publications, Cambridge, MA: Harvard University Press, 58-74

Torun B, Davies PSW, Livingstone MBE, Paolisso M, Sackett R, Spurr GB (1996): Energy requirements and dietary energy recommendations for children and adolescents 1 to 18 years old. *European Journal of Clinical Nutrition.* **50,** Suppl.1, S37-S81

Weiner JS, Lourie JA (1969): In: *Human Biology: A Guide to Field Methods.* I.B.P. Handbook, no. 9 Oxford: Blackwell Scientific Publications.

Chapter 3

Indices of weight status, physical activity and body image concerns of young Dublin adolescent schoolchildren.

3.1 Introduction.

The prevalence of childhood obesity is increasing rapidly around the world (WHO 1998). Obesity and overweight are associated with increased mortality and increased risk of chronic disease during adulthood (Pi-Sunyer 1991). There is limited evidence for an association between adolescent obesity and increased risks of adult morbidity and mortality (Must *et al* 1992). Fat distribution, or visceral fat, has been significantly related to disease risk factors in children and adolescents (Brambilla *et al* 1994). Furthermore, the socio-economic pathways for overweight adolescents appear to diverge from those of normal weight adolescents, especially among women (Gortmaker *et al* 1993). There has been no new information of body weight status among young Irish schoolchildren since the Irish National Nutrition Survey 1990 over ten years ago where 1.1% of boys and 2.6% of girls, aged 12-15 years, were identified as being at risk of overweight (Hurson and Corish 1997).

Assessments of the prevalence and trends of childhood overweight have been difficult to establish due to the lack of international criteria for classifying individuals as overweight or obese (Seidell 1999). Triceps skinfold closely relates to percentage body fat but is impracticable for epidemiological use (Roche *et al* 1981; Cole *et al* 2000). Weight-for-height indices are the most feasible and recently body mass index (BMI) for age and sex has emerged as a means of defining overweight among children (Dietz and Bellizze 1999). However, the range of cut-off values recommended for BMI-for-age give variation in the prevalence of overweight (Himes and Dietz 1994; Cole *et al* 2000; Kuczmarski *et al* 2000). In addition, one can use actual relative weight (ARW), another measure based on percentage of ideal body weight for age and sex (NCHS 1973; Roche 1984).

It is still a matter of debate whether there are particular stages in childhood, including puberty, during which physiological alterations increase the risk of later obesity (Dietz

1994). Obesity is often attributed to excess energy intake but, available evidence suggests that the trends in obesity rates are related more to time spent at sedentary activities and a reduction in energy expenditure than to an increase in caloric intake (Seidell 1999; Berkey *et al* 2000; Janz *et al* 2000).

Concurrent with the increasing prevalence of obesity among children is fear of fatness, particularly among young adolescent girls (Flynn 1997). Boys are more likely to try to gain weight compared to their female peers (Nowak *et al* 1996). Unhealthy eating and disordered eating behaviours among young adolescents have the potential to adversely affect nutrient intake, mental health status, and long-term health outcomes (Neumark-Sztainer and Hannon 2000). Unhealthy weight control practices reported among Irish adolescent girls (15 years old) include the random avoidance of staple foods, fasting, smoking and purging (Ryan *et al* 1998). Compared to those who do not diet, adolescent girls who diet at a severe level are 18 times more likely, and those who diet at a moderate level are 5 times more likely to develop an eating disorder (Patton *et al* 1999). Predictors of higher eating disorder scores for both sexes (reported at ages 6 to 14 years) include greater weight accompanied by shorter height, children's belief that their parents are concerned about their weight, low body esteem, and depression (Gardner *et al* 2000).

The purpose of this research was to examine underweight, normal weight and overweight trends in a one-year follow up study of Dublin schoolchildren and associated factors including socio-economic class (SEC), physical and sedentary activities, fear of fatness and slimming practices. Current definitions of weight-for-height cut-offs for determining weight status were compared with triceps skinfold measurements, which represent an independent measure of fatness.

3.2 Subjects and Methods.

3.2.1 Subjects.

Subjects were recruited for this study through Dublin city primary schools as described in chapters 2.1 and 2.2.

A random sample of 56% of the children recruited (*n* 251, 119 boys, 132 girls; 113 FP, 138 NFP; mean age 11 years), controlled equally for sex and school type attended, had indices of weight status measured and completed a questionnaire on physical activity. Seventy-nine percent of this random sample (*n* 199, 90 boys, 109 girls; 88 FP, 111 NFP; mean age 12 years) were successfully followed up during the second year.

3.2.2 Socio-economic class.

Social class was classified according to the highest classed earner within a household as described in chapter 2.5.4.

3.2.3 Physical activity and body image concerns.

Satisfaction with perceived body shape and slimming practices were reported using the questionnaire described in chapter 2.4.2 and 2.4.3. Sedentary activity was reported in terms of the frequency per week and duration per day using the same questionnaire. Physical activity was reported in the same terms as sedentary activity in a interview assisted questionnaire described in chapter 2.5.2 and 2.5.3.

3.2.4 Anthropometry.

Measurements were taken to assess actual body mass in terms of actual relative weight, BMI and body fat distribution as described in chapter and sub-sections 2.6. Table 1 gives the range of cut-offs available to define risk of overweight and overweight based on weight-for-height measurements. In addition, to allow comparison to previous Irish data (Hurson and Corish 1997) the proportion of 12-year-old subjects, in the present study, with a BMI >26kg/m^2 were identified as being at risk of overweight. In some cases an adequate measurement of skinfold could not be recorded due to the tightness of the subcutaneous fat to muscle (7% (n 6) boys and 12% (n 13) girls at age 11 years, and 9% (n 8) boys and 17% (n 18) girls at age 12 years).

3.2.5 Pubertal stage of maturation

Identification of early and late maturers was made using growth data as described in chapter 2.7

3.2.6 Data management and statistical analysis.

All data was coded for entry into the Statistical Package for Social Sciences (SPSS) version 10.0 for Windows. "Don't know" and "none of the above" answers were omitted from analysis. Variables that were not normally distributed (using tests of Kolmogorov-Smirnov Z) which included BMI, triceps skinfold and waist circumference were transformed (by taking the reciprocal or log) to achieve a normal distribution. Comparisons for the total group, sex and social class were made between year 1 (1999, at age 11 years) and year 2 (2000, at age 12 years) using the following statistics as appropriate; Wilcoxon Signed Rank, paired t-test, and McNemar. Variables were analysed according to sex and social class using χ^2 test, Mann-Whitney and independent t-test, as appropriate. Pearson's correlation was used to assess the strength of relationships between measures of growth and measures of adiposity. A significant difference was indicated by a p value ≤ 0.05.

3.3 Results.

Of the SEC1, 79.4% (*n* 77) attended fee-paying schools, whereas 78% (*n* 36) of SEC2 and 98% (*n* 53) of SEC3 attended non-fee-paying schools and, therefore, fee-paying (FP) represents the higher social class and non-fee-paying (NFP) the lower social classes.

Anthropometric measurements were taken on average 0.98 (0.1) years apart (range 0.75 - 1.23 years). As expected, significant differences existed for almost all anthropometric variables (reflecting growth) between 1999 and 2000 for the total group and for each category of sex and socio-economic class. The only variables that did not change in the one-year follow-up were the subscapular to triceps ratio (STR) among boys, FP and NFP subjects and the triceps skinfold measurement among FP subjects only. The difference in height gained by the boys was significantly greater than that gained by the girls (0.07 (0.02)m *vs*. 0.06 (0.02)m respectively, $p \leq 0.05$).

Table 2 outlines the growth parameters and indices of adiposity compared between the sexes in both years. On both occasions boys tended to be lighter and leaner than their female counterparts. The only significant difference noted between the social classes was at age 12 where NFP subjects, in comparison to FP subjects, had a higher STR (0.67(0.2) *vs*. 0.59(0.14), $p \leq 0.05$) and a higher mid-arm muscle area (339.2 (72.5)mm^2 *vs*. 320.4 (52)mm^2, respectively, $p \leq 0.05$).

The range in the proportion of subjects identified as overweight according to different definitions is shown in chart 1(a) for 1999 and 1(b) for 2000. In both years, BMI was found to correlate more strongly than ARW to triceps measurements (r -0.731 *vs*. r 0.606, at age 11 years; r -0.662 *vs*. r 0.581, at age 12 years). (It should be noted that the distribution of BMI was skewed and was transformed to give a normal distribution by taking the reciprocal of BMI. Therefore, the negative correlation of BMI to triceps demonstrates that as BMI increases so also does adiposity). However, in the present study, it was decided to use ARW to assess body weight status as this allowed use of Irish clinical growth charts. The other possibility, IOTF cut-offs that were developed as an internationally acceptable definition of child overweight, does not currently give recommended cut-off BMI values to define underweight (Cole *et al* 2000). Using the criterion of the Irish National Nutrition Survey 1990 (i.e. a BMI $>26kg/m^2$) it was found that 5.6% (*n* 6) boys and 6.4% (*n* 6) girls, aged 12 years, were at risk of overweight.

At ages 11 and 12 years it was respectively found that 30% (*n* 59) and 31% (*n* 62) were underweight, 45% (*n* 92) and 43% (*n* 85) were normal weight and that 25% (*n* 50) and 26% (*n* 52) were overweight according to ARW categories. At both ages a greater proportion of boys compared to girls were found to be underweight (at age 11 years: 36% (*n* 32) *vs*. 25% (*n* 27), respectively, $p \leq 0.05$; at age 12 years: 44% (*n* 40) *vs*. 20% (*n* 22), respectively, $p \leq 0.001$). Likewise, a smaller proportion of boys compared to girls were found to be overweight (at age 11 years: 17% (*n* 15) *vs*. 32% (*n* 35), respectively, $P \leq 0.05$; at age 12 years: 21% (*n* 19) *vs*. 30% (*n* 33), respectively, $p \leq 0.001$). SEC groups were comparable for body weight distribution. Overweight children were found to have greater adipose tissue centrally located than their normal weight counterparts (at age 11 years; WC: 71.2 (1.1)cm *vs*. 63.2 (1.1)cm, $p \leq 0.001$; STR: 0.64 (0.14) *vs*. 0.61 (0.14), *ns*; WHR: 0.82 (0.05) *vs*. 0.80 (0.09), $p = 0.05$; and at age 12 years, WC: 71.5 (1.1)cm *vs*. 65.1 (1.1)cm, $p \leq 0.001$; STR: 0.68 (0.3) *vs*. 0.61 (0.1), *ns*; WHR: 0.79 (0.06) *vs*. 0.77 (0.04), $p \leq 0.05$).

Table 3 presents the comparisons of indices of growth and adiposity between early and late maturers aged 12-years according to sex. Commencement of maturation among the boys or girls did not differ between different SEC. At age 11 years, 12% (*n* 13) of the girls reported reaching menarche increasing to 33% (*n* 36) at age 12 years. When these 36 girls (early maturers) were compared to non-menstruating girls (*n* 73) they were found to be older (12.3 (0.8)y *vs*. 11.8y (0.7)y, $p \leq 0.05$), heavier (52.8 (8.0)kg *vs*. 46.3

(9.0)kg, $p \leq 0.001$), taller (1.6 (0.06)m *vs*. 1.53 (0.07)m, $p \leq 0.001$), and fatter (triceps: 14.8 (0.1)mm *vs*. 12.2 (0.2)mm, $p \leq 0.05$, subscapular: 11.2 (3.4)mm *vs*. 8.0 (3.2)mm, $p \leq 0.001$), and show a change in fat patterns (WC: 67.5 (1.1)cm *vs*. 64.4 (1.1)cm, $p \leq 0.05$; WHR: 0.7 (0.03) *vs*. 0.8 (0.05), $p \leq 0.001$; STR: 0.7 (0.3) *vs*. 0.6 (0.2), $p \leq 0.05$) but there was no difference in ARW percentage (106.7 (19.3)% *vs*. 103.9 (19.2)%, *ns*).

Table 4 outlines the comparisons of perceived and preferred body shapes circled by the total group and classified according to sex, socio-economic class and age.

Over a quarter of the children expressed dissatisfaction with their perceived body shapes by indicating a preference towards thinness (29% (*n* 57) at age 11 years and 27% (*n* 55) at age 12 years). At age 12 years, it emerged that more girls expressed a desire for a thinner body shape than boys (39% (*n* 39) *vs*. 17% (*n* 15), $p \leq 0.05$ respectively), and girls were less likely to desire a heavier body shape than boys (4% (*n* 4) *vs*. 7% (*n* 6), respectively, $p < 0.05$). There was no SEC bias in either year.

Reported perceived body shape compared to categorised ARW weight status of the total group is shown in chart 2 (a) at age 11 years and (b) at age 12 years. These charts represent the inaccuracy with which actual body weight is perceived. In total, 47% (*n* 94) children perceived their body shape incorrectly, at age 11 years and 51% (*n* 102) perceived their body shapes incorrectly at age 12 years. At age 11 years, 25% (*n* 15) of underweight children (no sex difference found) reported an underweight figure as their preferred body shape. At age 12 years, 16% (*n* 10) of underweight children (no sex difference found) reported an underweight figure as their preferred body shape.

At age 11 and 12 years, respectively, overweight children (58% (*n* 29) and 54% (*n* 26)) were more likely to express a desire for a thinner shape ($p \leq 0.001$) than their normal weight (33% (*n* 19) and 32% (*n* 26)) and underweight counterparts (16% (*n* 9) and 5% (*n* 3)). Fifty-six percent (*n* 26) of overweight children reported they had tried to lose weight at age 11 years decreasing to 52% (*n* 27) a year later. Although comparable at age 11 years, at age 12 years twice as many of the overweight girls, compared to overweight boys, reported that they have tried to lose weight (70% (*n* 21) *vs*. 35% (*n* 6), respectively, $p \leq 0.05$). Twelve-year-old overweight girls were also more likely to desire a lighter body shape compared to age- and weight- matched boys (67% (*n* 20) *vs*. 33% (*n* 6), respectively, $p = 0.051$). Overweight boys and girls were comparable in their reported slimming practices on both occasions, except at age 12 years, where overweight boys were more likely to report avoiding meat compared to age- and weight- matched girls (27% (*n* 4) *vs*. 3% (*n* 1), respectively, $p \leq 0.05$).

Over half the girls, found to be early maturers based on menarche rather than height increments, expressed a desire for a thinner body shape compared to other girls (53% (*n* 18) *vs*. 24% (*n* 37), $p \leq 0.05$). Of these girls, half perceived themselves as overweight compared to a quarter of the non- menstruating girls (50% (*n* 17) *vs*. 25% (*n* 39), $p \leq 0.05$) but were, in fact, classified (according to ARW) as 17% (*n* 6) underweight, 53% (*n* 19), normal weight and 31% (*n* 11) overweight. Although, not a significant finding, it was interesting to note that among these early maturing girls 17% (*n* 1) who were underweight and 50% (*n* 9) who were normal weight perceived themselves to be overweight.

It was found that the same subjects reported trying to lose weight in the one-year follow-up (31% (*n* 62) at age 11 years and 30% (*n* 59) at age 12 years). At age 11 years, 14% (*n* 8) of underweight and 30% (*n* 26) of normal weight subjects reported that they have previously tried to lose weight. At age 12 years, 10% (*n* 6) of the underweight and 33% (*n* 26) of the normal weight subjects reported that they have tried to lose weight. Initial and one year follow-up showed more girls than boys report weight loss attempts (42% (*n* 45) *vs*. 20% (*n* 17) at age 11 years, $p \leq 0.05$; 41% (*n* 41) *vs*. 21% (*n* 21) at age 12 years, $p \leq 0.05$). FP and NFP schools were comparable for reported attempts at weight loss. More of the early maturing girls, based on reported menarche, report trying to lose weight compared to non-menstruating girls (50% (*n* 16) *vs*. 28% (*n* 43), $p \leq 0.05$) at age 12 years, whereas early maturing boys were comparable to their late maturing counterparts.

At ages 11- and 12-years old it was respectively found that reported slimming practices included: 78% (*n* 48) and 66% (*n* 39) eating less fatty foods, 63% (*n* 39) and 68% (*n* 40) doing more exercise, 53% (*n* 33) and 44% (*n* 26) eating less sugary foods, 27% (*n* 17) and 25% (*n* 15) drinking more water, and 13% (*n* 8) and 14% (*n* 8) skipping meals. There was no change of slimming practices reported among the sexes over the year. Comparisons between the SECs revealed that more FP compared to NFP children reported eating less fatty foods at age 11 years (68% (*n* 60) *vs*. 52% (*n* 58), $p \leq 0.05$). At age 12 years, more FP subjects, compared to NFP subjects, reported drinking more water (28% (*n* 24) *vs*. 13% (*n* 14), $p \leq 0.05$) and doing more exercise (73% (*n* 62) *vs*. 54% (*n* 58), $p \leq 0.05$). Of those early maturing girls who were trying to lose weight the majority report doing more exercise (69%, *n* 11), and eating less fatty food (63%, *n* 10). Of those children who expressed a desire to be thinner, it was found that 60% (*n* 34) at age 11 years, and 66% (*n* 36) at age 12 years, reported trying to lose weight with no difference between either sex or SEC.

The subjects (64% (*n* 127) at age 11 years and 62% (*n* 124) at age 12 years) that were considered to do vigorous exercise were comparable for sex and social class at both ages. The majority of these subjects reported a frequency of vigorous physical activity of more than five days a week (58% (*n* 74) at age 11 years and 61% (*n* 75) at age 12 years, *ns*). Most subjects reported that the duration of vigorous physical activity was a half-hour to two hours long per day (52% (*n* 66) at age 11 years and 55% (*n* 68) at age 12 years, *ns*). Sex and SECs were comparable for reported frequency and duration of vigorous physical activity in both years. Comparing underweight, normal weight and overweight categories of ARW and pubertal stages with activity found no relationship with the frequency or duration of time spent at physical activity.

The frequency (per week) and duration (per day) of time spent at sedentary activity (watching television/videos/computer games) at age 11 years and 12 years is shown according to sex and SEC in table 5. Underweight, normal weight and overweight children were comparable in reported frequency and duration of time spent sedentary.

A comparison between the intensity, amount of time spent at and the duration of physical activity per day and the amount of time spent at and the duration of sedentary activity per day did not establish that more active children were least sedentary and vice versa.

Table 1: The range of cut-off points, based on weight-for-height measurements, that are currently advised for defining risk of overweight and actually overweight among children and adolescents.

Weight-for-height index		Cut-off Risk of overweight	Cut-off Overweight
ARW	2 - 18 years	111 – 120 %	> 120 %
CDC BMI-for-age charts (kg/m^2)*	Males age 11 y	20.2	23.1
	Females age 11 y	20.8	24.1
	Males age 12 y	21.0	24.3
	Females age 12 y	21.7	25.2
Expert Committee 1994 (kg/m^2)	Males age 11 y	20	24
	Females age 11 y	21	25
	Males age 12 y	21	25
	Females age 12 y	22	26
IOTF (kg/m^2)	Males age 11 y	20.6	25.1
	Females age 11 y	20.7	25.4
	Males age 12 y	21.2	26.0
	Females age 12 y	21.7	26.7

ARW = Actual relative weight (NCHS 1978)
CDC = Centre for Disease Control BMI-for-age charts for boys and girls (Kuczmarski *et al* 2000)
Expert Committee on Clinical Guidelines for Overweight in Adolescent Preventative Services (Himes and Dietz 1994)
IOTF = International Obesity Task Force age and sex specific cut-offs (Cole *et al* 2000)
*Risk of overweight taken as $\geq 85^{th}$ percentile and $<95^{th}$ percentile; overweight taken as $\geq 95^{th}$ percentile (Kuczmarski *et al* 2000)

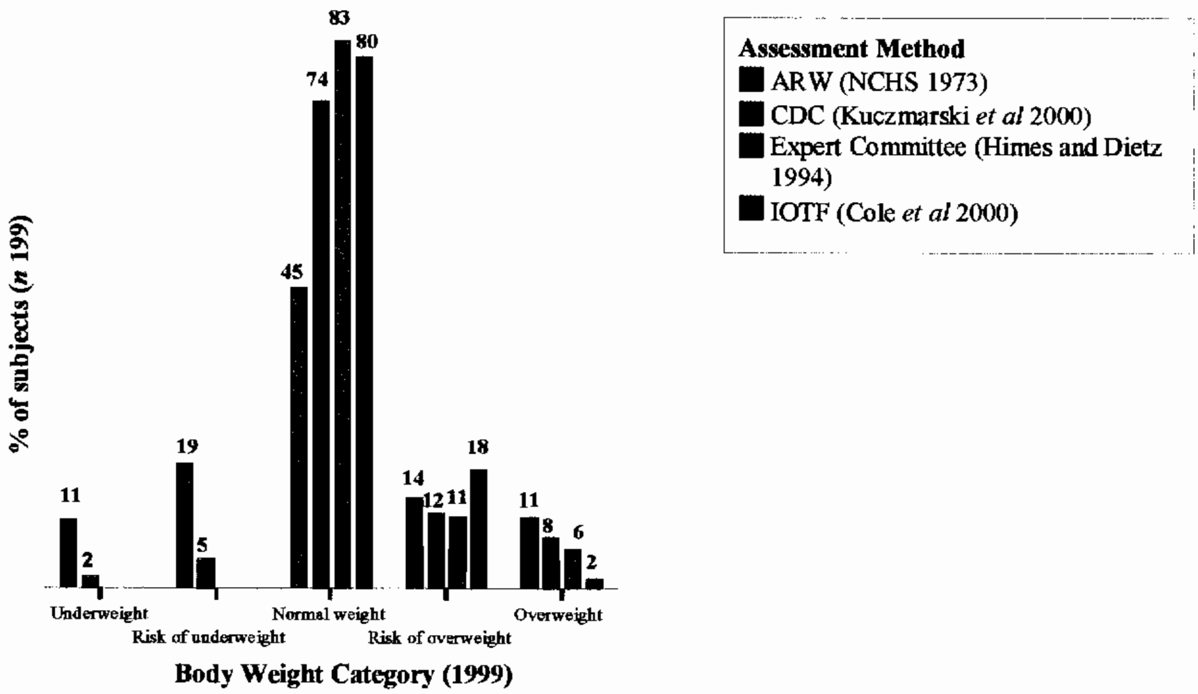
Table 2: Mean (standard deviation) indices of growth and adiposity of young Dublin adolescent schoolchildren (n 199, mean age 12 years at follow-up) from different social backgrounds according to sex in a one-year follow-up study.

Year	Age 11 years			Age 12 years		
	Total	Boys	Girls	Total	Boys	Girls
	(n 199)	(n 90)	(n 109)	(n 199)	(n 90)	(n 109)
	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
Weight (kg)	41.8 (8.4)	41.1 (8.2)	42.4 (8.5)	47.5 (9.5)	46.7 (9.8)	48.2 (9.2)
Height (m)	1.5 (0.07)	1.5 (0.06)	1.5 (0.07)	1.6 (0.07)	1.6 (0.08)	1.6 (0.07)
Triceps$^{\$}$ (mm)	11.8 (0.1)	10.9 (0.2)	13.4 (0.1)**	12.3 (0.1)	11.3 (0.2)	13.9 (0.1)**
Subscap$^{\$}$ (mm)	8.1 (3.4)	7.3 (3.3)	8.8 (3.2)**	8.6 (3.5)	7.3 (2.7)	9.7 (3.7)**
MAC (cm)	22.6 (2.9)	22.2 (3.1)	23.1 (2.8)*	23.2 (2.8)	23.1 (3)	23.4 (2.7)
WC (cm)	64.4 (1.1)	64.5 (1.1)	64.3 (1.1)	65.9 (1.1)	66.5 (1.1)	65.4 (1.1)
WHR	0.8 (0.08)	0.82 (0.075)	0.79 (0.081)**	0.8 (0.05)	0.8 (0.038)	0.75 (0.043)**
MAMC (cm)	18.2 (1.6)	18.2 (1.8)	18.1 (1.6)	18.5 (1.7)	18.7 (1.8)	18.3 (1.6)
AMA (mm^2)	319.7 (58.9)	320 (65.3)	318.9 (53)	331.1 (65)	340 (69.7)	323.1 (59.7)
STR	0.62 (0.14)	0.6 (0.1)	0.6 (0.1)	0.64 (0.18)	0.6 (0.2)	0.7 (0.2)
BMI (kg/m^2)	18.18 (0.08)	17.7 (0.01)	18.5 (0.01)*	19.01 (0.08)	18.4 (0.01)	19.5 (0.01)*
ARW (%)	99.7 (16.6)	97.7 (15.7)	101.4 917.3)	100.8 (18.3)	95.9 (15.9)	104.8 (19.2)**

*Significantly different from boys ($p \leq 0.05$), **Significantly different from boys ($p \leq 0.001$), MAC = Mean arm circumference, MAMC = Mid arm muscle circumference, AMA - Mid-arm muscle area, WC = waist circumference, WHR = Waist to hip ratio, STR = Subscapular to triceps ratio; ARW = actual relative weight $^{\$}$Inadequate data excluded from assessment: at age 11 years; triceps (*n* 17, 5 boys and 12 girls); subscaps (*n* 9 (3 boys and 6 girls): at age 12 years; triceps (*n* 23, 7 boys and 16 girls); subscaps (*n* 14, 6 boys and 8 girls).

Chart 1: Proportions (%) of young adolescent schoolchildren (n 199, 90 boys, 109 girls) assessed as underweight and normal weight, at risk of overweight and overweight according to four different methods of assessment at (a) age 11 years and (b) age 12 years.

(a) mean age 11 years



(b) mean age 12 years

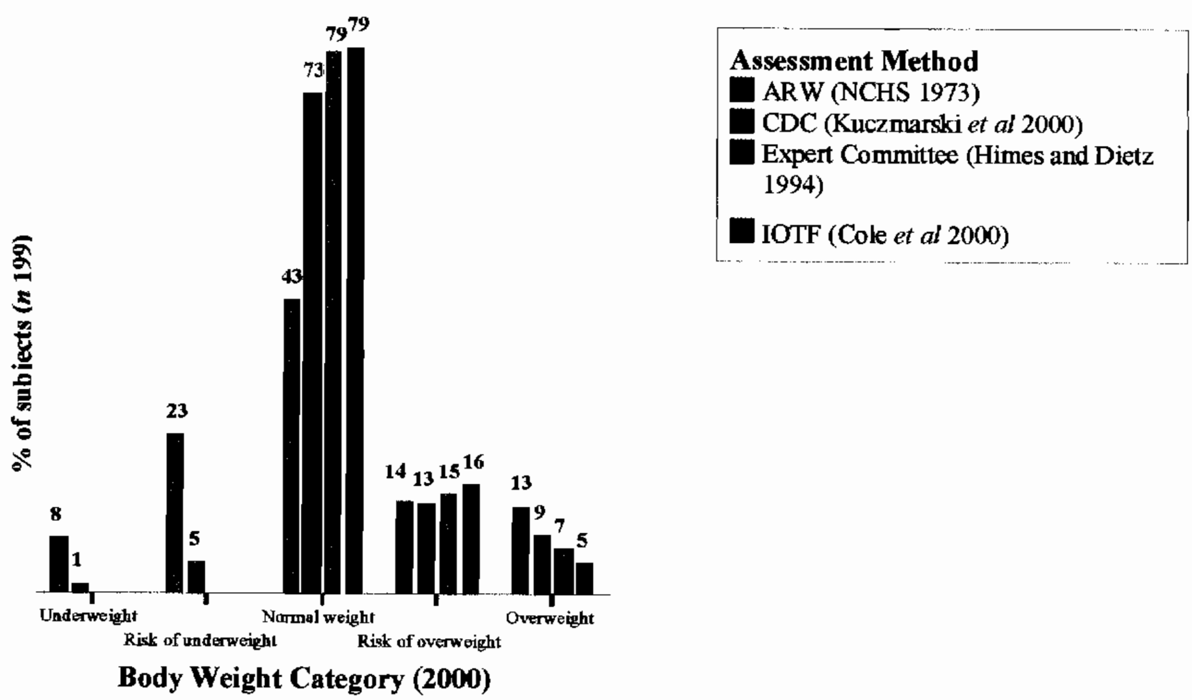


Table 3: Indices of growth and adiposity in early maturing (height increment $\geq$ 0.07 m) boys (*n* 90) and in early maturing (height increment $\geq$ 0.06 m and reported menarche) girls (*n* 109) compared to late maturing counterparts at age 12 years.

Variable	Boys (*n* 90)		Girls (*n* 109)	
	Early maturation (*n* 40) Mean (SD)	Late maturation (*n* 50) Mean (SD)	Early maturation (*n* 78) Mean (SD)	Late maturation (n 31) Mean (SD)
Age (y)	12.1 (0.8)	11.9 (0.8)	12 (0.8)	11.7 (0.7)
Weight (kg)	50.2 (9.1)	43.9 (9.5)*	48.6 (8.3)	47.3 (11.1)
Height (m)	1.6 (0.1)	1.5 (0.1)**	1.56 (0.06)	1.52 (0.08)*
Triceps (mm)	10.6 (0.1)	11.9 (0.2)	13.6 (0.14)	14.7 (0.13)
Subscaps (mm)	7.3 (2.7)	7.2 (2.7)	9.8 (3.6)	9.7 (4.1)
MAC (cm)	23.4 (2.9)	22.7 (3.2)	23.5 (2.6)	23.3 (2.9)
MAMC (cm)	19.5 (1.9)	18.0 (1.5)**	18.4 (1.5)	17.8 (1.8)
AMA (mm^2)	371.6 (74.5)	314.5 (54.1)**	329.1 (57.9)	307.8 (62.8)
WC (cm)	67.8 (1.1)	65.4 (1.1)	65.3 (1.1)	65.7 (1.1)
WHR	0.79 (0.1)	0.81 (0.1)*	0.75 (0.04)	0.76 (0.04)
STR	0.7 (0.2)	0.6 (0.1)*	0.67 (0.22)	0.6 (0.13)
BMI (kg/m^2)	18.8 (0.01)	18.1 (0.01)	19.4 (0.006)	19.7 (0.008)
ARW (%)	92.4 (15.2)	98.8 (16.0)	102.3 (18.0)	111.2 (20.7)*
After one year:				
Weight change(kg)	7.1 (3.2)	4.4 (2.6)	6.04 (2.7)	5.1 (2.6)
Height change(m)	0.09 (0.02)	0.05 (0.01)**	0.07 (0.02)	0.04 (0.01)**
Triceps change(mm)	-0.6 (2.5)	1.6 (2.5)**	0.48 (3.2)	1.2 (1.9)
Subscaps change(mm)	0.01 (1.6)	0.4 (2.1)	1.14 (1.6)	0.7 (1.8)*
Waist change (cm)	2.2 (3.0)	1.7 (3.2)	1.1 (3.6)	1.1 (3.3)

* Significantly different from early maturers ($p \leq 0.05$), ** Significantly different from early maturers ($p \leq 0.001$); MAC = Mean arm circumference, MAMC = Mid arm muscle circumference, AMA - Mid-arm muscle area, WC = waist circumference, WHR = Waist to hip ratio, STR = Subscapular to triceps ratio; ARW = actual relative weight

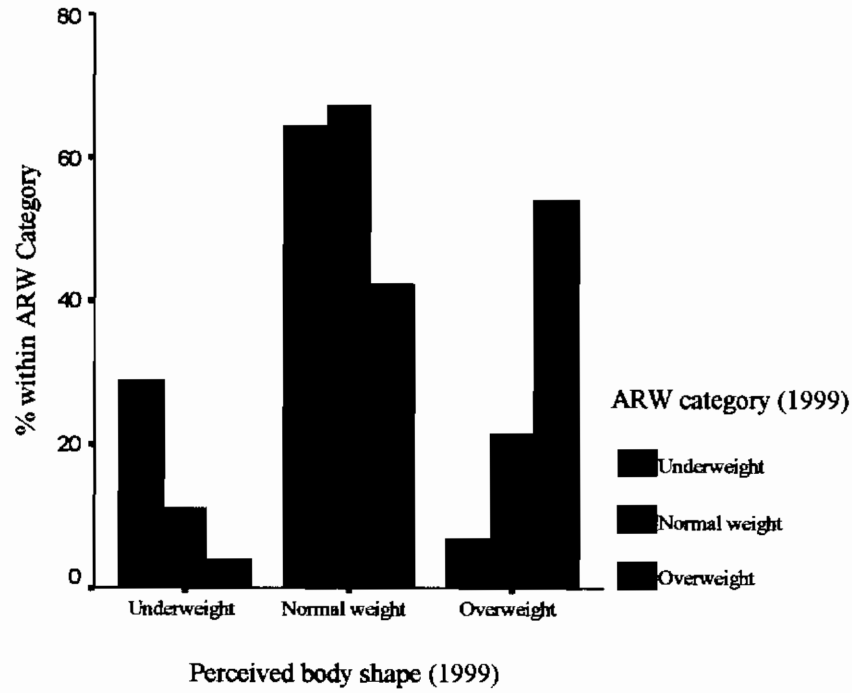
Table 4: A comparison of perceived and preferred body shape categories between sex and social class (represented as school type attended) as reported by young Dublin adolescent schoolchildren in a one-year follow-up study

	Total (n 199) % (n)	Boys (n 90) % (n)	Girls (n 109) % (n)	FP (n 88) % (n)	NFP (n 111) % (n)
<u>Age 11 years</u>					
Perceived body shape					
Underweight	15 (29)	16 (14)	14 (15)	18 (16)	12 (13)
Normal weight	60 (119)	62 (55)	59 (64)	61 (54)	59 (65)
Overweight	25 (50)	23 (20)	28 (30)	21 (18)	29 (32)
Preferred body shape					
Underweight	19 (38)	19 (17)	19 (21)	28 (25)	12 (13)*
Normal weight	70 (140)	69 (61)	73 (79)	67 (59)	74 (81)*
Overweight	10 (20)	12 (11)	8 (9)	5 (4)	15 (16)*
<u>Age 12 years</u>					
Perceived body shape					
Underweight	11 (21)	11 (10)	11 (11)	12 (10)	10 (11)
Normal weight	58 (115)	65 (57)	56 (58)	59 (25)	61 (65)
Overweight	28 (56)	24 (21)	34 (35)	29 (25)	29 (31)
Preferred body shape					
Underweight	12 (24)	12 (10)	14 (14)	14 (12)	11 (12)
Normal weight	74 (147)	74 (64)	81 (83)	79 (66)	76 (81)
Overweight	10 (19)	15 (13)	6 (6)	7 (6)	12 (13)

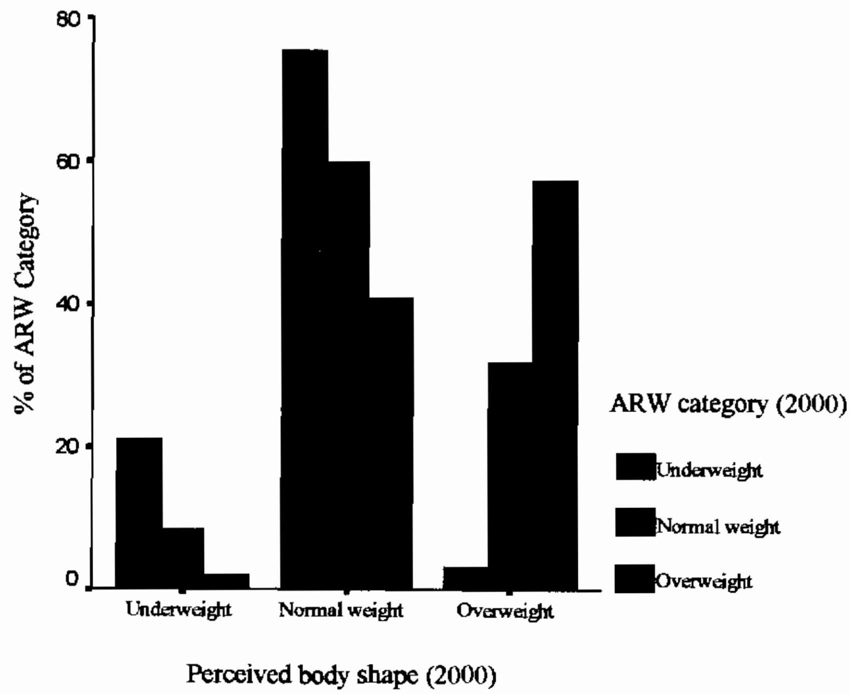
*Significantly different from fee-paying schools, $p \leq 0.05$; FP = fee-paying school; NFP = non-fee-paying school.

Chart 2: Proportions (%) of adolescent schoolchildren at (a) age 11 years and (b) age 12 years according to ARW categories (underweight, normal weight and overweight) compared with their self-perceived weight status

(a) mean age 11 years



(b) mean age 12 years



ARW = actual relative weight.

Table 5: The reported frequency (days/week) and duration (hours/day) of sedentary activities (watching TV/videos/playing computer games) according to sex and social class (represented as school type attended) as reported by young Dublin adolescent schoolchildren at age 11 years and, one-year later, at age 12 years.

	Total (*n* 199) % (*n*)	Boys (*n* 90) % (*n*)	Girls (*n* 109) % (*n*)	FP (*n* 88) % (*n*)	NFP (*n* 111) % (*n*)
Age 11 years					
Frequency					
$\leq$ 2 days/week	33 (66)	46 (40)	24 (26)$^{\$}$	19 (17)	45 (49)**
3 to 4 days/week	47 (93)	39 (34)	54 (59)$^{\$}$	64 (56)	34 (37)**
$\geq$ 5 days/week	19 (38)	16 (14)	22 (24)$^{\$}$	17 (15)	21 (23)**
Duration					
0 to 2 hours/day	47 (93)	46 (34)	69 (59)$^{\$}$	77 (56)	43 (37)**
3 to 4 hours/day	24 (48)	37 (27)	25 (21)$^{\$}$	19 (14)	40 (34)**
5 to 6 hours/day	9 (18)	18 (13)	6 (5)$^{\$}$	4 (3)	17 (15)**
Age 12 years					
Frequency					
$\leq$ 2 days/week	78 (155)	87 (74)	80 (81)	79 (63)	87 (92)
3 to 4 days/week	11 (21)	6 (5)	16 (16)	16 (13)	8 (8)
$\geq$ 5 days/week	5 (10)	7 (6)	4 (4)	5 (4)	6 (6)
Duration					
0 to 2 hours/day	52 (103)	67 (42)	72 (61)	72 (61)	57 (43)*
3 to 4 hours/day	18 (36)	24 (15)	25 (21)	25 (21)	33 (25)*
5 to 6 hours/day	5 (9)	10 (6)	4 (3)	4 (3)	9 (7)*

$^{\$}$ Significantly different from boys, $p \leq 0.05$
*Significantly different from fee-paying schools, $p \leq 0.05$
** Significantly different from fee-paying schools, $p \leq 0.001$

3.4 Discussion

In the 10 years since the last reported estimate, a 5-fold increase among boys (1.1-% (n 1) vs. 5.6% (n 6)) and a 2.5 fold increase among girls (2.6% (n 3) vs. 6.4% (n 7)) in the prevalence of overweight has occurred among a young Irish population. Using the same criterion to define overweight as that used by the Irish National Nutrition 1990 (Hurson and Corish 1997) validates this increase. Depending on which definition is used, a varied range (2 – 11% at age 11 years, 5 – 13% at age 12 years) in the prevalence of overweight is achieved within the same group of young adolescents (both males and females). Twelve-year-old boys and girls reported dissatisfaction with their body shape but where boys desired a heavier shape, girls desired a thinner shape. Fear of fatness was found to be prevalent among overweight individuals and among young adolescent girls, in particular those girls at an advanced maturational stage. Exercise was one of the most commonly reported methods of weight loss and, contrary to other literature, no difference was found in sedentary and physical activities according to body weight categories or sex.

The increase in overweight reported among 12-year-old Irish boys and girls compares to the growing prevalence of overweight and obesity documented in other industrialised countries (Troiano *et al* 1995; Hughes *et al* 1997; WHO 1998). The Irish National Nutrition Survey 1990 defined risk of overweight among adolescents, irrespective of age and sex, as a BMI cut-off of 26kg/m^2 which actually corresponds to the cut-off of 18-year-old females (Hurson and Corish 1997; Himes and Dietz 1994). Therefore, it could be assumed that the actual prevalence of risk of overweight in 1990 was probably higher than that reported. The Expert Committee cut-offs were based on a single data-set of the US adolescent population and have been superseded by the CDC BMI-for-age charts (Himes and Dietz 1994; Kuczmarski *et al* 2000). In order to establish trends in child obesity, it is important to take regular measurements that are based on consistent age- and sex-specific criteria (Cole *et al* 2000), particularly if trends from different geographical regions are to be compared.

The term obesity describes a condition characterised by excessive body fat whereas overweight defines excess body mass (Himes and Dietz 1994). The definitive methods of assessing body fat in young adolescents correlate to skinfold measurements and include dual-energy x-ray absorptiometry (DEXA) and body composition by under-water weighing, but these are expensive and not practical for population surveys (Dietz and Belizz 1999). Skinfold measurements, that quantify body fat, also have disadvantages in that they require trained investigators where reliability is consistently monitored. They can be considered invasive and are time consuming, and are not possible to measure accurately in fatter individuals, as was found in this study among 10% (*n* 19) of subjects at age 11 years and 13% (*n* 24) at age 12 years. Although less sensitive, weight and height are cheap, quick and easy measurements of body mass and do not cause physical discomfort.

The exact measures used, referent populations, and cut-offs used provide different results between populations and, in order to quantify and compare childhood obesity internationally, a commonly accepted standard is required. Actual relative weight was used to assign the subjects to age- and sex-specific criteria of body weight status using Irish Clinical Growth Charts (Hoey *et al* 1986). This approach, however, assumes that the distribution of weight within an age group is identical to that within a corresponding stature group. Baseline stature and weight are highly correlated within age groups, the distribution and resultant percentiles of weight-for-stature are narrower than those of weight-for-age. Hence, the matching procedure will systematically overestimate the target weight of adolescents (Himes and Dietz 1994). Indeed, using ARW to define overweight among the present group of 12-year-old children found that 13% (*n* 26) were overweight compared to 5% (*n* 10) as defined by IOTF cut-offs (chart 1(b)).

Body mass index, which the IOTF cut-offs represent, significantly correlate more strongly than ARW with subcutaneous and total body fatness in adolescents as reported in this study and others (Malina and Katzmarzyk 1999), as well as being recognised internationally as a definition of adult body mass status (WHO 1995). Therefore, the prevalence of overweight among these Dublin schoolchildren is perhaps more accurately reported according to the IOTF cut-offs. In addition, the IOTF cut-offs are recommended for use in international comparisons of prevalence of overweight and obesity and are linked to the widely accepted adult cut-off points of a BMI of 25 and 30kg/m^2 (Cole *et al* 2000).

However, the current IOTF recommendations do not give cut-offs for defining underweight (Cole *et al* 2000). Malnutrition secondary to avoidance of certain foods can lead to serious disorders such as osteopenia, anaemia, and syndromes related to deficiencies of vitamins, minerals, essential fatty acids, and trace elements (Rogol *et al* 2000). The risks posed by low weight are detrimental and because weight loss attempts are shown to go hand-in-hand with fear of fatness even among underweight girls (Ryan *et al* 1998) it is critical to have a criterion of underweight especially when assessing growth and defining weight status.

Potentially, given the number of children measured, the many years over which data have been gathered, the multi-racial nature of the data and the advanced statistical procedures involved (Kuczmarski *et al* 2000) the CDC BMI-for-age charts offer the most accurate reference to establish prevalence of overweight between populations that would also allow an estimation of underweight. Accordingly, overweight prevalence may be reported among 11- and 12-year-old Dublin schoolchildren as 8% (*n* 16) and 9% (*n* 18) respectively.

Increasingly, studies are being published that show secular trends in increasing rates of overweight that are accompanied by increased disease risk (Pi-Sunyer 1991; Troiano *et al* 1995; Hughes *et al* 1997; WHO 1998). Adiposity and cardiovascular risk factors track from childhood into adulthood and early identification of children with high central adiposity is therefore important (Wattigney *et al* 1995; Taylor *et al* 2000). It is currently unclear whether increasing adiposity in children and adolescents is related to increasing deposition of intra-abdominal adipose tissue (IAAT) and whether the amount of IAAT accumulation seen in children is appropriate for their body size (Goran and Gower 1999). Waist circumference rather than WHR, which correlates well with IAAT in adults, provides a simple and effective measure of truncal adiposity (measured by DEXA and CT scanning) in children and adolescents (Goran *et al* 1998; Taylor *et al* 2000). Correlations between IAAT and trunk-to-extremity, or the STR, are not as strong as those between IAAT and WC among children (Goran *et al* 1998). The overweight children, in the present study were found to have more fat centrally located compared to their normal weight counterparts, based on measurements of both WC and WHR but not STR, and may, therefore, be at increased disease risk factors (Brambilla *et al* 1994).

Adiposity, except STR and MAMA at age 12 years, and body mass was not found to differ between the SECs. No clear association between SEC and childhood fatness is reported in the literature but a strong consistent positive relationship between lower socio-economic class (SEC) of origin and subsequent adult obesity is indicated (Parsons *et al* 1999). Socio-economic status did not influence the prevalence of dissatisfaction with body shape among this group either. It could be implied that being overweight is socially undesirable whatever the SEC background and that this could be the result of sociocultural influences, namely peer, media and family influences to alter weight (Field *et al* 2001).

Fear of fatness, expressed as a desire to be thinner, was found to relate to weight loss attempts. Besides the unhealthy implications of slimming practices, including permanent short stature (Pugliese *et al* 1983), risk of osteoporosis and nutritional deficiencies (Flynn 1997; Rogol *et al* 2000), there are serious mental health issues involved where strict dieting has recently been associated to the development of eating disorders (Patton *et al* 1999).

The level of reported dissatisfaction with body shape did not change over the year. Among both sexes, making considerable effort to look like same-sex figures in the media has been reported to be predictive of developing weight concerns and becoming a constant dieter (Field *et al* 2001). Fear of fatness was found to affect more girls than boys and to increase among the girls with increasing age in the present study. It has been suggested that the female biological/physical changes in adipose tissue distribution may trigger dissatisfaction (Rosen and Gross 1987). The body parts (hips, thighs, waist, and stomach) mentioned by girls in previous studies are the same parts that concern adult women, reflecting the fashionable pre-pubescent shape for females (Nowak *et al* 1996). This may explain the differences reported in this study between the girls at a late stage of puberty who were found to have a more gluteal distribution of adipose tissue, than those who had not reached menarche.

Boys also expressed dissatisfaction with their body shapes indicating a desire to be heavier that differed significantly from girls in the one-year follow-up. Among overweight children, boys were less likely to report attempts to lose their excess weight. This could be interpreted as a desire for increased muscularity conforming to culturally dictated and stereotyped physical ideals for men to be muscular and large (Rosen and Gross 1987; Moore *et al* 1990).

At the older age of 12 years, it was found that the majority (67% (*n* 20) of overweight girls, compared to overweight boys, reportedly desired a thinner body shape and twice as many report trying to lose weight. A study of 526 children aged 9-11-years in the US suggested an association between childhood obesity and four hallmarks of disordered eating - dieting, restricted eating, fear of being or becoming overweight and body image dissatisfaction (Vander Wal and Thelen 2000). Whilst avoidance of obesity is recognised as a healthy practice, given the risk of future chronic disease associated with childhood obesity (Pi-

Sunyer 1991; Must *et al* 1992), the inappropriate dieting and weight-loss behaviours known to accompany fear of fatness in adolescent girls may actually pose a far greater threat to their health than obesity (Flynn 1997).

The majority of schoolchildren in this study reported exercise levels that resemble those advocated for a physically active life that aims to reduce the risk of morbidity and mortality (Sothern *et al* 1999). No association was found between reported physical and sedentary activity and body shape. A limitation to the present study was that physical and sedentary activities were reported by questionnaire, not observed, and as such cannot be validated. Another possibility is that given the large number of overweight subjects who expressed desires towards thinness, and the finding that exercise constituted a popular slimming practice, usual physical and sedentary activity may have been masked among these individuals.

A recent comprehensive review of the literature suggests that activity may protect against, and inactivity promote, the development of obesity (Parsons *et al* 1999). Overweight among schoolchildren has been attributed to more time spent sedentary and less time spent physically active rather than to increased caloric intakes (Seidell 1999; Berkey *et al* 1998). An ongoing study of greater than 10,000 boys and girls from all over the US showed that boys and girls who spent more time viewing TV and videos and playing video/computer games during a one-year follow-up had larger increases in BMI (Berkey et al 2000). Tracking of most physical fitness and physical activity variables, from childhood to adolescence, has been reported as moderate to high among boys but unchanged or even decreased among girls (Janz *et al* 2000). Therefore, Irish public health initiatives should be directed to encourage young adolescent girls to maintain their current rate of exercise as they grow older. In addition, boys were found to spend more time watching TV more frequently than girls at age 11 years, in the present study. Although this did not persist one year later it is reported elsewhere that boys classified as sedentary, based on initial measurements of TV viewing and video game playing, were 2.2 times more likely than their peers to be classified as sedentary at follow-up (Janz *et al* 2000). Non-fee-paying children, representing the lower socio-economic class, consistently reported spending more time sedentary over the two years. There was no difference between the socio-economic classes in relation to body weight status or reported physical activity.

A further limitation of the present study was the lack of actual assessment of maturational stage of the boys and girls. It was possible to estimate height increments (shown in table 3 and taken on average one year apart (range 0.75 - 1.23 years) which should avoid seasonal variation in growth (Olivieri *et al* 1993) that may, otherwise, have influenced results) as a crude determination between early and late maturers. The use of height increments as a criterion of maturational stage needs to be interpreted with much caution as individuals differ much in the magnitude of their growth spurts (Tanner 1989). In addition those girls who reported reaching menarche added another measure of maturational stage. When these girls (based on menarche only) were compared with late maturers they were found to be older and therefore, it is possible that the differences found in indices of adiposity are likely to be related to their greater chronological age in addition to maturation. However, they were found to have significantly greater indices of fatness reflecting the rapid accumulation of fat that occurs in girls postmenarche (Rogol *et al* 2000) with distinctive fat patterning mainly in the gluteal area but they were not found to have a greater body mass (in text, p124). Early maturation among girls has been associated with negative self-body image (Siegel *et al* 1999). This relatively positive response to a prepubescent body is consistent with the thinner and less curvaceous ideal held by many teenage girls (Nowak *et al* 1996; Siegel *et al* 1999). In boys, significant increases in lean body mass exceed the total gain in weight because of a concomitant loss of adipose tissue (Rogol *et al* 2000) and this was reflected by the significant differences in the change of triceps skinfold between the early and late maturers and the lack of difference in weight gain (see table 3).

Despite reported levels of physical activity we can conclude that obesity among Irish schoolchildren is increasing. Given this finding there is an urgency to adopt an acceptable standard of defining overweight among Irish children which is representative of actual prevalence. Based on current methods available the CDC BMI-for-age charts seem the most valid means. This could be used in combination with WC, which may allow screening of possible future chronic disease that is associated with increased IAAT in adulthood. But, body weight dissatisfaction was reported among both boys and girls. There are clear implications, therefore, for the development of weight loss programmes and health promotion initiatives, such as National Healthy Eating Weeks and programmes such as the Nutrition Education at Primary Schools (NNSC 1997), that tackle healthy eating without exacerbating the fear of fatness expressed particularly among older girls and overweight children.

3.5 References

Berkey CS, Rockett HRH, Field AE, Gillman MW, Frazier AL, Camargo CA, Colditz GA (2000): Activity, dietary intake, and weight changes in a longitudinal study of preadolescent and adolescent boys and girls. *Pediatrics.* **105(4),** URL: http://www.pediatrics.org/cgi/content/full/105/4/e56

Brambilla P, Manzoni P, Sironi S, Simone P, Del Maschio A, di Natale B, Chuimello G (1994): Periheral and abdominal adiposity in childhood obesity. *International Journal of Obesity.* **18,** 795-800

Cole TJ (1991): Weight-stature indices to measure underweight, overweight, and obesity. In: Himes JH (ed) *Anthropometric Assessment of Nutritional Status.* Wiley-Liss, New York, 83-111

Cole TJ, Bellizzi MC, Flegal KM, Dietz WH (2000): Establishing a standard definition for child overweight and obesity worldwide: international survey. *British Medical Journal.* **320**, 1240-1243

Dietz WH (1994): Critical periods in childhood for the development of obesity. *American Journal of Clinical Nutrition.* **59**, 955-959

Dietz WH, Bellizze MC (1999): Introduction: the use of body mass index to assess obesity in children. *American Journal of Clinical Nutrition.* **70,** Suppl., 123S-125S

Field AE, Camargo CA, Taylor CB, Berkey CS, Roberts SB, Colditz GA (2001): Peer, parent, and media influences on the development of weight concerns and frequent dieting among preadolescent and adolescent girls and boys. *Pediatrics.* **107,** 54-60

Flynn MAT (1997): Fear of fatness and adolescent girls: implications for obesity prevention. *Proceedings of the Nutrition Society.* **56,** 305-317

Gardner RM, Stark K, Friedman BN, Jackson NA (2000): Predictors of eating disorder scores in children ages 6 through 14: A longitudinal study. *Journal of Psychosomatic Research.* **49,** 199-205

Goran Mi, Gower BA, Treuth M, Nagy TK (1998): Prediction of intra-abdominal and subcutaneous adipose tissue in healthy prepubertal children. *International Journal of Obesity.* **22,** 549-558

Goran MI, Gower BA (1999): Relation between visceral fat and disease risk in children and adolescents. *American Journal of Clinical Nutrition.* **70,** suppl. 149S-156S

Gortmaker SL, Must A, Perrin JM, Sobal AM, Dietz WH (1993): Social and economic consequences of overweight in adolescence and young adulthood. *New England Journal of Medicine.* **329,** 1008-1012

Himes JH, Dietz WH (1994): Guidelines for overweight in adolescence preventive services: recommendations from an expert committee. *American Journal of Clinical Nutrition.* **59,** 307-316

Hoey H, Tanner JM, Cox LA (1986): *Irish Clinical Growth Standards, Girls: Birth - 19 years, Height and Weight* and *Boys: Birth - 19 years, Height and Weight.* Castlemead Publications : Herts., Dublin, Ref. 312

Hughes JM, Li L, Chinn S, Rona RJ (1997): Trends in growth in England and Scotland, 1972 to 1994. *Archives of Diseases of Childhood.* **76,** 182-189

Hurson M, Corish C (1997): Evaluation of lifestyle, food consumption and nutrient intake patterns among Irish teenagers. *Irish Journal of Medicine and Science.* **166(4)**, 225-230

Janz KF, Dawson JD, Mahony LT (2000): Tracking physical fitness and physical activity from childhood to adolescence: the Muscatine study. *Medicine and Science in Sports and Exercise.* **32(7),** 1250-1257

Kuczmarski RJ, Ogden CL, Grummer-Strawn LM, Flegal KM, Guo SS, Wei R, Curtin LR, Roche AF, Johnson CL. (2000): CDC growth charts: United States. Advance data from vital and health statistics; no.314. Hyattsville, Maryland: National Center for Health Statistics http://www.cdc.gov/nchs/

Malina RM, Katzmarzyk PT (1999): Validity of the body mass index as an indicator of the risk and presence of overweight in adolescents. *American Journal of Clinical Nutrition.* **70,** 131-165

Moore DC (1990): Body image and eating behaviour in adolescent boys. *American Journal of Diseases in Childhood.* **8,** 593-596

Must A, Jacques PF, Dallal GE, Bajema CJ, Dietz WH (1992): Long-term morbidity and mortality of overweight adolescents. A follow-up of the Harvard Growth Study of 1922 to 1935. *New England Journal of Medicine.* **327**, 1350-1355

National Centre for Health Statistics (1973): *Height and Weight for Youths, 12 - 17 Years, United States.* US Department of Health: Bethesda, MD. Education and Welfare Series **11**, No. 24

National Nutrition Surveillance Centre (1997): *A Review of the Health Promotion Framework for Action Nutrition Plan.* National University of Ireland: Galway

Neumark-Stzainer D, Hannan, PJ (2000): Weight-related behaviours among adolescent girls and boys: Results from a national survey. *Archives of Pediatric and Adolescent Medicine.* **154**, 569-577

Nowak M, Speare R, Crawford D (1996): Gender differences in adolescent weight and shape-related beliefs and behaviours. *Journal of Paediatric and Childhood Health.* **32**, 148-152

Olivieri MB, Ladizesky M, Mautalen CA, Alanso A, Martinez L (1993): Seaonal variation in Ushuaia (Argentina), the southernmost city of the world. *Bone Mineralisation.* **20,** 99-108

Parsons TJ, Power C, Logan S, Summerbell CD (1999): Childhood predictors of adult obesity: a systematic review. *International Journal of Obesity.* **23,** Suppl 8, S1-S107

Patton GC, Selzer R, Coffey C, Carlin JB, Wolfe R (1999): Onset of adolescent eating disorders: population based cohort study over three years. *British Medical Journal.* **318,** 765-768

Pi-Sunyer FX (1991): Health implications of obesity. *American Journal of Clinical Nutrition.* **53**, 1595S-1603S

Pugliese M, Lifshitz F, Grad G, Fort P, Marks-Katz M (1983): Fear of obesity. *New England Journal of Medicine.* **309,** 513-518

Roche AF, Siervogel RM, Chumlea WC, Webb P (1981): Grading adiposityness from limited anthropometric data. *American Journal of Clinical Nutrition.* **34,** 2831-2838

Roche AF, Tyleshevs.ki F, Rogers E (1983): Non-invasive measurement of physical maturity in children. *Research Quarterly for Sport and Exercise.* **54,** 364-371

Rogol AD, Clark PA Roemmich JN (2000): Growth and pubertal development in children and adolescents: effects of diet and physical activity. *American Journal of Clinical Nutrition.* **72(suppl)**, 521S-528S

Rosen JC, Gross J (1987): Prevalence of weight reducing and weight gaining in adolescent girls and boys. *Health Psychology.* **6(2),** 131-147

Ryan YM, Gibney MJ, Flynn MAT (1998): The pursuit of thinness: a study of Dublin schoolgirls aged 15y. *International Journal of Obesity.* **22,** 485-487

Seidell JC. (1999): Obesity: a growing problem. *Acta. Pediatrics.* **Suppl 428**, 46-50

Siegel JM, Yancey AK, Aneshensel CS, Schuler R (1999): Body image, perceived pubertal timing, and adolescent mental health. *Journal of Adolescent Health.* **25,** 155-165

Sothern MS, Loftin M, Suskind RM, Udall JN, Blecker U (1999): The health benefits of physical activity in children and adolescents: implications for chronic disease prevention. *European Journal of Pediatrics.* **158,** 271-274

Tanner JM (1989): Puberty. In: *Foetus into man: Physical growth from conception to maturity.* (2nd ed.) Castlemead Publications, Cambridge, MA: Harvard University Press, 58-74

Taylor RW, Jones IE, Williams SM, Goulding A (2000): Evaluation of waist circumference, waist-to-hip ratio, and the conicity index as screening tools for high trunk fat mass, as measured by dual-energy X-ray absorptiometry, in children aged 3-19y. *American Journal of Clinical Nutrition.* **72,** 490-495

Troiano RP, Flegal KM, Kuczmarski RJ, Campbell SM, Johnson CL (1995): Overweight prevalence and trends for children and adolescents. The National Health and Nutrition Examination Surveys, 1963 to 1991. *Archives of Pediatric and Adolescent Medicine.* **149,** 1085-1091

Vander Wal J, Thelen MH (2000): Eating and body image concerns among obese and average-weight children. *Addictive Behaviours.* **25(5),** 775-778

Wattigney WA, Webber LS, Srinivasan SR, Berenson GS (1995): The emergence of clinically abnormal levels of cardiovascular disease risk factor variables among young adults: the Bogalusa Heart Study. *Preventive Medicine.* **24,** 617-626

World Health Organisation (1995): *Physical status: the use and interpretation of anthropometry.* Geneva: WHO

World Health Organisation (1998): *Obesity: preventing and managing the global epidemic.* Report of a WHO consultation, Geneva, 3-5 Jun 1997. Geneva: WHO (WHO/NUT/98.1)

Chapter 4

Macronutrient intakes and associated body image concerns of young Dublin schoolchildren.

4.1 Introduction.

Adolescence is a time of significant change in lifestyle and food habits that affect both nutrient intake and requirements (Strain *et al* 1994). Indeed, during adolescence, nutrient needs are high to facilitate rapid growth of bones, body tissues, the brain and sexual maturation. During puberty, adolescents gain 20% of their adult height and 50% of their adult weight and skeletal mass, with girls depositing twice as much body fat as boys while boys double their lean body mass (Wahl 1999).

There is a growing awareness of the possible connection between the diets consumed by children and adolescents and diseases in adulthood. Diets high in fat have been found to contribute to overweight and obesity (Bray and Popkin 1998). Despite the large methodological differences in assessing dietary intakes in Western Europe, similarities are comparable in various geographical areas with respect to an intake of high fat (especially saturated fat), low carbohydrate, high animal protein, and low intake of fibre (Rolland-Cachera *et al* 2000).

Despite the unique methodological challenges posed, it is tacitly assumed that currently available dietary survey methods, which were constructed for use in an adult population, are also appropriate for collecting data from a paediatric population (Livingstone and Robson 2000). Children can be reliable reporters of their food intake but under-reporting is associated with increasing age and body weight measures (Livingstone and Robson 2000). The diet history is not a standardised technique, and despite good validity at the group level it is clearly prone to significant problems of precision at the individual level; it measures only memory and perception of usual diet, is subjective and vulnerable to socially-desirable responding, and is time-consuming to record (Livingstone and Robson 2000). It is recognised that multiple food frequency questionnaires and 24h recalls would be required to accurately estimate nutrient intake given the extent of variability in food intake observed in children and adolescents (Nelson *et al* 1989; Miller *et al* 1991; Livingstone and Robson 2000).

Ultimately, all dietary survey methods are dependent on the motivation, compliance and ability of the subjects to accurately report habitual food intake (Torun *et al* 1996). The doubly-labelled water method (a measure of habitual energy expenditure) is too expensive and technically challenging to be routinely used to validate energy intake data. Therefore, cut-offs that evaluate energy intake data by comparison with presumed energy requirements have been developed for assessing validity of group and individual energy intake data (Black *et al* 1991; Goldberg *et al* 1991; Torun *et al* 1996). A trend for under-reporting dietary intake has been found to occur among heavier children consistent with trends found among adults (Fisher *et al* 2000; Braam *et al* 1998; Livingstone *et al* 1992). Selective mis-reporting of certain types of food (for example, biscuits/pastries/puddings and sugar/confectionery) has been shown to affect the macronutrient composition of the reported diet among adults (Pryer *et al* 1997). Psychological measures related to weight and eating, such as children's body satisfaction and weight concerns, may shed light on children's susceptibility to report dietary intakes in a socially desirable manner (Fisher *et al* 2000).

The purpose of this study was to examine the issue of under-reporting among a group of young Dublin schoolchildren from different socio-economic backgrounds in a one-year follow-up study by using established estimates that have been based on equations of minimal physical activity levels that are considered compatible with lifestyle. An attempt was made to characterise those who under-report energy intake in terms of their body image concerns and their actual weight status, and therefore explore the association of these factors with reporting dietary intakes.

4.2 Subjects and Methods.

4.2.1 Subjects.

Subjects were recruited for this study through Dublin city primary schools as described in chapters 2.1 and 2.2. This study represents a random sample of 55% of the children recruited (*n* 239, 110 boys, 129 girls, mean age 11 years), controlled equally for sex and schooltype who completed a questionnaire, had measurements of anthropometry taken and recorded dietary intake. One year later 77% of this random sample (*n* 185, 79 boys, 106 girls, mean age 12 years) repeated the study in a one-year follow-up.

4.2.2 Socio-economic class.

Social class was classified according to the highest classed earner within a household as described in chapter 2.5.4.

4.2.3 Anthropometry.

Measurements were taken to assess actual body mass in terms of actual relative weight, body mass index and body fat distribution as described in chapter 3 (section 3.2.4). Basal metabolic rate was estimated according to sex, age and weight using established equations (FAO/WHO/UNU 1985; Schofield 1985).

4.2.4 Dietary intake.

Each subject kept a food diary for two days from which mean daily nutrient intakes were estimated as described in chapter and sub-sections 2.8. Under- and over-reporters of energy intake were identified from cut-offs described in chapter 2.8.6.

4.2.5 Body image concerns.

Body image concerns, including satisfaction with body shape and slimming practices, were assessed using the questionnaire described in chapter 3.2.3.

4.2.6 Data management and statistical analysis.

Each food diary was coded using food codes described in chapter 2.8.5 and analysed using WISP, version 1.26, a nutritional package for Windows (Tinuviel Software). Consumers (%) of foods and the mean daily intake (g/d) of foodstuffs/drinks consumed were identified. All data was coded for entry into the Statistical Package for Social Sciences (SPSS) version 10.0 for Windows. Nutritional data from WISP was merged with questionnaire data in SPSS for statistical analysis. "Don't know" and "none of the above" answers were omitted from analysis. Variables that were not normally distributed (using tests of Kolmogorov-Smirnov Z) were transformed by taking the log (to the base of 10) to achieve normal distribution. Comparisons within the total group, according to sex and social class and differences between age 11 years and age 12 years were made using the following statistics as appropriate; Wilcoxon Signed Rank, paired t-test. Variables were analysed according to sex, SEC, body weight category, and adequacy of dietary reporting using χ^2 test, Mann-Whitney, independent t-test and one-way ANOVA, as appropriate. A significant difference was indicated by a p value ≤ 0.05.

4.3 Results.

Eighty- percent (*n* 97) of SEC1 attended FP schools whereas 72% (*n* 36) of SEC2 and 98% (*n* 62) of SEC3 attended NFP schools. Therefore, schooltype is used as a proxy for SEC. The mean (SD) weight of boys and girls, respectively, was 41.8 (8.9)kg and 42.6 (8.5)kg at age 11 years old, and 46.8 (9.8)kg and 48.3 (9.2)kg at age 12 years old. The mean (SD) BMI of boys and girls was, respectively, 18.4 (3.0)kg/m^2 and 18.9 (3.0)kg/m^2 at age 11 years and 18.9 (3.1)kg/m^2 and 19.9 (3.2)kg/m^2 at age 12 years old. Girls had a higher BMI than boys at age 12 years ($p \leq 0.05$).

Eleven-year-old boys and girls were classified according to actual relative weight as underweight (10% (*n* 11) *vs.* 12% (*n* 16), $p \leq 0.05$), slightly underweight (23% (*n* 25) *vs.* 13% (*n* 17), $p \leq 0.05$), normal weight (47% (*n* 52) *vs.* 42% (*n* 55), $p \leq 0.05$), slightly overweight (9% (*n* 10) *vs.* 20% (*n* 26), $p \leq 0.05$) and overweight (12% (*n* 13) *vs.* 12% (*n* 16), $p \leq 0.05$) respectively. Twelve-year-old boys and girls were classified according to actual relative weight as underweight (10% (*n* 9) *vs.* 7% (*n* 7), $p \leq 0.05$), slightly underweight (32% (*n* 28) *vs.* 13% (*n* 14), $p \leq 0.05$), normal weight (36% (*n* 31) *vs.* 50% (*n* 54), $p \leq 0.05$), slightly overweight (15% (*n* 13) *vs.* 13% (*n* 14), $p \leq 0.05$) and overweight (7% (*n* 6) *vs.* 18% (*n* 19), $p \leq 0.05$) respectively.

The mean daily intakes of energy and macronutrients by the total group are presented in Table 1 according to age and sex. The reported energy intake and the energy composition was comparable between under-, normal- and over-weight subjects at both age 11 and 12 years (data not shown). At age 11 years, fewer of the overweight children compared to those of normal weight reported consuming chocolate confectionery (68% (n 44) *vs.* 83% (n 89), $p \leq 0.05$) and non-chocolate confectionery (52% (n 34) *vs.* 71% (n 76), respectively, $p \leq 0.05$). At age 12 years, the overweight group reported that they were less likely than the normal weight group to consume cakes and pastries (29% (n 15) *vs.* 55% (n 47), respectively, $p \leq 0.05$).

At age 11 years, 32% of the children (*n* 73; 53 girls *vs.* 20 boys, $p \leq 0.05$) reported that they have previously tried to lose weight and were identified as dieters. At age 12 years, 33% (*n* 57; 40 girls *vs.* 17 boys, $p \leq 0.05$) were identified as dieters. Chi-square analysis reveals that overweight children (64%, *n* 18) were more likely to report weight loss attempts compared to those who were slightly overweight (49%, *n* 17), normal weight (29%, *n* 30), slightly underweight (13%, *n* 5) and underweight (16%, *n* 4) groups at age 11 years ($p \leq 0.001$). Similarly, when children were 12-years-old, chi-square analysis reveals that weight loss attempts were reported by more overweight children (77%, *n* 17) compared to those who were slightly overweight (42%, *n* 10), normal weight (32%, *n* 25), slightly underweight (12%, *n* 5), and underweight (6%, *n* 1; $p \leq 0.001$). Reported slimming practices among the combined group of slightly overweight and overweight children did not differ between 11 and 12 years of age and included the following practices (from most to least reported): "do more exercise", "eat less fatty foods", "eat less sugary foods", "drink more water", and "skip meals".

Characteristics of under-reporters (EI:BMR < 1.39 (boys) and EI:BMR < 1.30 (girls)) compared to adequate (EI:BMR 1.39-2.24 (boys) and EI:BMR 1.30-2.10 (girls)) and over-reporters (EI:BMR > 2.24 (boys) and EI:BMR > 2.10 (girls)), in terms of reported demographics, body image concerns, and indices of weight are shown in table 2 according to age. The EI:BMR was skewed among girls at age 12 years and therefore log transformation was used for analysis to achieve a normal distribution. Although comparable for sex and SEC, it can be seen that children in the under-reporting category, compared to children in the adequate and over-reporting categories, were heavier and had more adiposity, were significantly less satisfied with their body shape, were more likely to desire a thinner shape and to attempt weight loss.

In general EI:BMR decreases significantly with increasing relative weight among the total and each sex group (see table 3(a)). In each sex and age group, except for slightly overweight girls aged 11 years, the EI:BMR of the slightly overweight and overweight groups fall below the cut-offs that identify under-reporting. In contrast to table 3(a), in table 3(b) "dieters" have been excluded from the analysis. The EI:BMR becomes comparable between each category of actual relative weight according to sex when this group is excluded from analysis. However, the EI:BMR of the overweight boys and girls, at age 11 years, remain lower than the cut-offs (table 3(b)). At age 12 years, the EI:BMR of the overweight boys and girls would be accepted but those of the slightly overweight groups would not. The three-week interval between dietary recordings allowed identification of weight gained or lost in that interval. At age 11 and age 12 years the mean weight gained during each interval was comparable between actual relative weight categories (range 0.3-0.7kg gained at age 11 years and 0.1-0.7kg gained at age 12 years). At age 11 years, the slightly overweight group reported fewer meals per day compared to the normal weight group (2.3 (0.5) *vs.* 2.7 (0.6) meals/day, respectively, $p \leq 0.05$). Otherwise, the number of meals and snacks, and the reported frequency and duration of both sedentary and physical activities were comparable between actual relative weight categories at age 11 and 12 years.

Table 4 outlines the energy composition of dietary intakes reported by young Dublin schoolchildren compared between categories of under-, adequate- and over-reported intakes according to age. In terms of energy composition, under-reporters of energy intake had a higher percentage of protein and a lower percentage of sugar intakes at age 11 and 12 years and a higher percentage of starch and fibre intakes at age 12-years old compared to adequate reporters whereas, no differences were found for percentage fat intakes (Table 4). Data for the median daily intakes (for consumers only) of those foods in the 47 different categories of foodstuffs/drinks examined, emerged as being eaten differently in terms of the quantities consumed (g/d), and of those foods which emerged as being eaten by different proportions (% consumers) of under- and adequate- reporters are shown in table 5(a) for 11-year-olds and table 5(b) for 12-year-olds. Differences in the energy composition may be accounted for by the higher amount of fish (at age 11 years), and the lower amount of chocolate and non-chocolate confectionery (at ages 11 and 12 years) and lower amount of biscuits (at age 12 years) reported by under-reporters when compared with adequate reporters of energy intake.

Table 1: Mean daily intake and standard deviation (SD) of energy and macronutrients reported by young Dublin adolescents according to age and sex.

Variable	Total group		Boys		Girls	
	Age 11y (n 239) Mean (SD)	Age 12y (n 185) Mean (SD)	Age 11y (n 110) Mean (SD)	Age 12y (n 79) Mean (SD)	Age 11y (n 129) Mean (SD)	Age 12y (n 106) Mean (SD)
Energy (MJ/d)	8.0 (2.1)	8.0 (2.4)	8.3 (2.2)	8.4 (2.3)	7.8 (2.0)	7.7 (2.4)*
MJ/kg/d	0.2 (0.1)	0.2 (0.1)	0.2 (0.1)	0.2 (0.1)	0.2 (0.1)	0.2 (0.1)
% protein[$]	13.3 (3.0)	13.5 (3.0)	13.5 (2.6)	13.7 (3.1)	13.1 (3.3)	13.4 (3.0)
Protein (g/d)	62.0 (18.2)	63.1 (22.1)	65.0 (18.8)	67.3 (23.7)	59.5 (17.3)*	60.0 (20.4)*
% fat	37.7 (5.3)	37.9 (5.7)	37.5 (5.3)	38.1 (6.0)	37.8 (5.3)	37.8 (5.5)
Fat (g/d)	79.9 (25.2)	80.5 (28.4)	82.1 (25.3)	84.7 (27.3)	78.1 (25.0	77.4 (29.0)
% SFA	15.2 (3.5)	14.8 (3.6)†	15.4 (3.5)	14.9 (3.5)	15.1 (3.5)	14.7 (3.6)
SFA (g/d)	32.4 (12.0)	31.6 (13.1)	33.8 (12.2)	33.5 (13.6)	31.2 (11.6)	30.1 (12.5)
% PUFA	5.4 (1.7)	6.1 (2.2)†	5.3 (1.6)	6.2 (2.3)†	5.4 (1.8)	6.1 (2.2)
PUFA (g/d)	11.3 (4.8)	13.0 (6.1)†	11.6 (4.8)	13.4 (5.0)†	11.1 (4.7)	12.6 (6.8)
% MUFA	12.0 (2.2)	12.6 (2.5)†	12.1 (2.2)	13.1 (2.5)†	12.0 (2.2)	12.2 (2.4)*
MUFA (g/d)	25.6 (8.9)	26.7 (10.2)	26.7 (9.2)	28.9 (9.5)	24.8 (8.5)	25.1 (10.4)*
% CHO	48.4 (5.5)	48.2 (6.0)	48.4 (5.5)	47.8 (6.0)	48.5 (5.6)	48.5 (6.1)
CHO (g/d)	248.7 (72.0)	245.8 (78.2)	256.8 (74.0)	256.7 (80.5)	241.8 (69.7)	237.6 (75.8)
% starch	26.0 (4.7)	26.4 (5.2)	26.4 (4.3)	26.2 (5.6)	25.8 (5.0)	26.5 (5.0)
Starch (g/d)	130.5 (40.0)	132.1 (44.1)	136.0 (41.3)	138.1 (45.9)	125.9 (38.3)*	127.7 (42.4)
% sugars[$]	22.4 (5.5)	21.8 (6.1)	21.4 (0.1)	21.6 (6.0)	22.0 (0.1)	22.0 (6.2)
Sugars (g/d)	114.4 (43.6)	111.6 (46.9)	116.2 (45.1)	116.3 (49.6)	113.0 (42.3)	108.1 (44.8)
Fibre/4.2MJ	7.1 (2.0)	7.1 (2.1)	7.1 (2.0)	6.9 (2.0)	7.1 (2.0)	7.3 (2.1)
EI:BMR (PAL)	1.47 (0.4)	1.33 (0.2)	1.44 (0.4)	1.34 (0.2)	1.50 (0.4)	1.38 (0.4)

[$]transformed by log to normal distribution; SFA = saturated fatty acids; PUFA = polyunsaturated fatty acids; MUFA = monounsaturated fatty acids; CHO = carbohydrates; EI:BMR = energy intake to basal metabolic rate; PAL = physical aetivity level; *Significantly different from boys, $p \leq 0.05$; †Significantly different from 11-year-olds within group

Table 2: Observed indices of weight status, reported demographics and body image concerns of young Dublin adolescent schoolchildren according to category$ of reported energy intake in a one year follow-up study (age 11 and 12 years).

	Age 11 years (n 239)			Age 12 years (n 185)		
	Under-reporters	Adequate reporters	Over-reporters	Under-reporters	Adequate reporters	Over-reporters
	(n 94)	(n 127)	(n 18)	(n 93)	(n 82)	(n 10)
	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
Weight (kg)†	46.3 (9.4)^a	39.8 (7.3)^b	37.1 (2.9)^b	50.1 (10.4)^a	45.4 (8.1)^b	44.0 (6.9)^b
Actual relative weight (%)†	103.3 (17.6)^a	97.8 (16.9)^b	98.3 (12.7)	105.6 (20.0)^a	97.4 (15.9)^b	96.7 (18.5)
BMI (kg/m^2)†	19.9 (3.4)^a	18.0 (2.6)^b	17.4 (1.5)^b	20.4 (3.6)^a	18.7 (2.3)^b	18.0 (2.1)^b
Waist circumference (cm)†	68.5 (8.2)^a	63.2 (6.4)^b	60.4 (3.5)^b	68.7 (8.2)^a	63.9 (5.6)^b	62.7 (5.6)^b
Triceps skinfolds (mm)†	14.5 (5.1)^a	12.4 (4.1)^b	11.4 (3.0)^b	14.3 (4.7)	12.8 (4.6)	13.1 (2.8)
Energy (MJ/d)†	6.3 (1.2)^a	8.6 (1.3)^b	12.2 (2.2)^c	6.4 (1.5)^a	9.2 (1.5)^b	12.4 (3.1)^c
EI:BMR$_{est}$ $†	1.07 (0.2)^a	1.62 (0.2)^b	2.47 (0.3)^c	1.06 (0.2)^a	1.63 (0.2)^b	3.09 (2.0)^c
	% (n)	% (n)	% (n)	% (n)	% (n)	% (n)
Males	55 (52)	41 (52)	33 (6)	48 (45)	40 (33)	10 (1)
Females	45 (42)	59 (75)	68 (12)	52 (48)	60 (49)	90 (9)
Fee-paying schools	44 (41)	50 (63)	33 (6)	44 (41)	46 (38)	50 (5)
Non-fee-paying schools	56 (53)	50 (64)	67 (12)	56 (52)	54 (44)	50 (5)
Satisfied with body shape	51 (47)*	67 (85) *	78 (14) *	58 (51) *	70 (55) *	90 (9) *
Prefer a thinner shape	44 (40) *	21 (27) *	11 (2) *	39 (34) *	22 (17) *	---
Prefer a heavier shape	5 (4) *	12 (15) *	11 (2) *	3 (3) *	9 (7) *	10 (1) *
Have tried to lose weight	44 (40) *	24 (29) *	22 (4) *	38 (33)	30 (23)	10 (1)

$Category derived according to the ratio of energy intake to estimated basal metabolic rate where: under-reporters have a ratio <1.39 (boys) and <1.30 (girls); adequate reporters 1.39-2.24(boys) and 1.30-2.10 (girls); over-reporters have a ratio > 2.24 (boys) and > 2.10 (girls). †One-way ANOVA, $P \leq 0.05$; Means with different superscripts are significantly different. *Chisquare, $p \leq 0.05$.

Table 3(a): Mean reported energy intake:estimated energy expenditure (EI:BMR_{est}) and standard deviations (SD) in young Dublin adolescent schoolchildren according to sex, age and actual relative weight category in a one year follow-up study (11- and 12-years).

	Actual Relative Weight Category									
Sex	ARW < 80%		ARW 80-90%		ARW 90-110%		ARW 110-120%		ARW >120%	
Age 11 years	n	Mean (SD)	n	Mean (SD)	n	Mean (SD)	n	Mean (SD)	n	Mean (SD)
All	27	1.52 (0.5)[a]	42	1.51 (0.5)[b]	106	1.54 (0.4)[c]	35	1.40 (0.4)[d]	29	1.17 (0.3)
Male	11	1.55 (0.4)[ae]	25	1.45 (0.5)[b]	52	1.54 (0.4)[cf]	9	1.18 (0.3)	13	1.11 (0.2)
Female	16	1.50 (0.5)	17	1.60 (0.5)	54	1.56 (0.4)	26	1.48 (0.5)	16	1.22 (0.4)
Age 12 years										
All	14	1.50 (0.1)[a]	37	1.50 (0.2)[bg]	82	1.33 (0.1)[c]	25	1.25 (0.1)	25	1.10 (0.2)
Male	7	1.50 (0.4)	24	1.43 (0.4)	30	1.41 (0.4)	12	1.27 (0.4)	6	1.06 (0.4)
Female	7	1.54 (0.1)	13	1.76 (0.3)[b]	52	1.32 (0.1)[h]	13	1.29 (0.1)[i]	19	1.14 (0.1)

ARW = Actual relative weight; Significance taken at $P \leq 0.05$ (ANOVA); [a] ARW < 80% significantly different from ARW > 120%; [b] ARW 80-90% significantly different from ARW > 120%; [c] ARW 90-110% significantly different from ARW >120%; [d] ARW 111-120% significantly different from ARW > 120%; [e] ARW <80% significantly different from ARW 111-120%; [f] ARW 90-110% significantly different from ARW 111-120%; [g] ARW 80-90% significantly different from ARW >120%; [h] ARW 80-90% significantly different to ARW 90-110%, [i] ARW 80-90% significantly different from ARW 111-120

Table 3(b): Mean reported energy intake:estimated energy expenditure (EI:BMR_{est}) and standard deviations (SD) in young Dublin adolescent schoolchildren excluding dieters[$] according to sex, age and actual relative weight category in a one year follow-up study (11- and 12-years).

	Actual Relative Weight Category									
Sex	ARW < 80%		ARW 80-90%		ARW 90-110%		ARW 110-120%		ARW >120%	
Age 11 years	n	Mean (SD)	n	Mean (SD)	n	Mean (SD)	n	Mean (SD)	n	Mean (SD)
All	21	1.51 (0.5)[a]	34	1.57 (0.5)[b]	73	1.62 (0.4)[c]	18	1.47 (0.5)	10	1.17 (0.2)
Male	10	1.55 (0.4)	23	1.47 (0.5)	40	1.57 (0.4)	6	1.26 (0.3)	6	1.12 (0.2)
Female	11	1.48 (0.6)	11	1.78 (0.5)	33	1.68 (0.4)	12	1.58 (0.5)	4	1.23 (0.3)
Age 12 years										
All	13	1.54 (0.4)	32	1.78 (1.4)	52	1.48 (0.4)	13	1.18 (0.4)	5	1.54 (0.7)
Male	6	1.51 (0.4)	21	1.46 (0.4)	23	1.49 (0.4)	7	1.25 (0.5)	2	1.42 (0.3)
Female	7	1.57 (0.4)	11	2.39 (2.2)	29	1.48 (0.4)	6	1.10 (0.3)	3	1.61 (0.9)

$Dieters are those children who reported that they have tried to lose weight (53 girls *vs*. 20 boys at age 11 years, $p \leq 0.05$, and 40 girls *vs*. 17 boys, $p \leq 0.05$, at age 12 years); ARW = actual relative weight; Significance taken at $P \leq 0.05$ (ANOVA); [a] ARW < 80% significantly different from ARW > 120%; [b] ARW 80-90% significantly different from ARW > 120%; [c] ARW 90-110% significantly different from ARW >120%

Table 4: Mean reported daily intake and standard deviation (SD) of energy and contribution by macronutrients to energy reported by young Dublin adolescent schoolchildren according to age (11- and 12-years) and reporting category[$].

Variable	Age 11 years			Age 12 years		
	Under-reporters (*n* 94)	Adequate reporters (*n* 127)	Over-reporters (*n* 18)	Under-reporters (*n* 93)	Adequate reporters (*n* 82)	Over-reporters (*n* 10)
	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
EI:BMR	1.07 (0.2)[a]	1.62 (0.2)[b]	2.47 (0.26)[c]	1.06 (0.2)[a]	1.63 (0.2)[b]	3.09 (2.0)[c]
Energy (MJ/d)	6.3 (1.2)[a]	8.6 (1.3)[b]	12.2 (2.2)[c]	6.4 (1.5)[a]	9.2 (1.5)[b]	12.4 (3.1)[c]
MJ/kg/d	0.1 (0.03)[a]	0.2 (0.04)[b]	0.3 (0.07)[c]	0.1 (0.030)[a]	0.2 (0.05)[b]	0.3 (0.08)[c]
% protein	14.3 (3.4)[a]	12.8 (2.6)[b]	11.7 (2.0)[b]	14.1 (3.3)[a]	12.9 (2.6)[b]	13.2 (2.1)
% fat	37.6 (5.8)	37.5 (5.1)	39.3 (4.1)	37.5 (5.9)	38.4 (5.3)	38.4 (7.0)
% SFA	15.1 (4.0)	15.1 (3.2)	16.5 (3.2)	14.3 (3.5)	15.4 (3.4)	14.5 (4.7)
% PUFA	5.5 (2.0)	5.3 (1.5)	5.3 (1.6)	6.3 (2.3)	6.0 (2.1)	6.2 (2.6)
% MUFA	12.2 (2.4)	11.8 (2.2)	12.7 (1.9)	12.6 (2.6)	12.6 (2.2)	12.2 (3.3)
% CHO	47.7 (5.5)	49.0 (5.7)	48.6 (4.0)	47.9 (6.2)	48.5 (5.6)	47.9 (8.3)
% starch	26.6 (4.6)	25.7 (4.6)	25.7 (5.9)	27.4 (5.8)[a]	25.0 (4.2)[b]	27.0 (4.9)
% sugars	21.1 (5.0)[a]	23.3 (5.7)[b]	22.9 (6.1)	20.5 (6.0)[a]	23.5 (6.0)[b]	20.9 (4.7)
Fibre/4.2MJ	7.3 (2.1)	7.0 (2.0)	7.1 (1.2)	7.5 (2.2)[a]	6.6 (2.0)[b]	7.0 (1.6)

[$]Reporting category derived as the ratio of energy intake to estimated basal metabolic rate where: under-reporters have a ratio <1.39 (boys) and <1.30 (girls); adequate reporters 1.39-2.24(boys) and 1.30-2.10 (girls); over-reporters have a ratio > 2.24 (boys) and > 2.10 (girls). SFA = saturated fatty acids; PUFA = polyunsaturated fatty acids; MUFA = monounsaturated fatty acids; CHO = carbohydrates; EI:BMR = energy intake to basal metabolic rate; [a,b,c]One-way ANOVA $p \leq 0.05$: Means with different superscripts are significantly different

Table 5(a): Median and range reported intake values (grams per day) for consumers only of foodstuffs eaten in significantly different quantities by under-reporters and adequate reporters[$] at age 11 years; and the proportions (%) of these and other significant foodstuffs eaten by these groups.

	Food intakes (g/d) among consumers only			Percentage consuming foodstuffs		
	Under-reporters	Adequate reporters		Under-reporters	Adequate reporters	
	Median (range)	Median (range)	p value	%	%	p value
Brown bread	13 (6-38)	25 (9-109)	< 0.0001	27	28	ns
Cakes and pastries	22 (3-150)	35 (7-151)	0.001	38	53	0.041
Full fat milk	150 (13-675)	218 (16-1083)	0.017	67	69	ns
Dairy ice-cream	17 (6-66)	24 (6-128)	0.027	32	36	ns
Fish and fish dishes	50 (8-93)	25 (4-94)	0.007	23	24	ns
Sugar, syrups and preserves	5 (1-29)	9 (1-74)	0.002	60	74	0.029
Chocolate confectionery	20 (2-108)	34 (1-201)	0.001	77	80	ns
Non-chocolate confectionery	11 (1-142)	15 (1-85)	0.009	49	76	$\leq$0.0001
Tea	138 (30-450)	225 (25-3100)	0.049	30	32	ns
Other breads	16 (4-50)	22 (4-192)	ns	14	28	0.014
Other breakfast cereals	20 (5-100)	22 (5-200)	ns	25	42	0.007
Ham, pork and bacon	24 (4-133)	30 (4-120)	ns	46	61	0.029
Processed meats	26 (5-125)	33 (3-124)	ns	53	73	0.003
Soups and sauces	38 (1-300)	33 (4-195)	ns	52	68	0.025

[$]reporting category derived as the ratio of energy intake to estimated basal metabolic rate where: under-reporters have a ratio <1.39 (boys) and <1.30 (girls); adequate reporters 1.39-2.24(boys) and 1.30-2.10 (girls); over-reporters have a ratio > 2.24 (boys) and > 2.10 (girls)

Table 5(b): Median and range reported intake values (grams per day) for consumers only of foodstuffs eaten in significantly different quantities by under-reporters and adequate at age 12 years; and the proportions (%) of these and other significant foodstuffs eaten by these groups.

	Food intakes (g/d) among consumers only			Percentage consuming foodstuffs		
	Under-reporters	Adequate reporters		Under-reporters)	Adequate reporters	
	Median (range)	Median (range)	p value	%	%	p value
White bread	50 (13-153)	67 (8-189)	0.01	86	94	ns
Plain and fancy biscuits	12 (2-85)	21 (2-71)	0.007	44	51	ns
Full fat milk	150 (19-545)	213 (25-819)	0.06	66	76	ns
Low fat milk	150 (25-838)	225 (7-550)	ns	37	21	0.030
Milk shakes	75 (75-75)	100 (60-157)	ns	1	11	0.007
Cheese	16 (3-59)	30 (4-133)	0.001	44	54	ns
Boiled, baked and mashed potatoes	63 (19-250)	88 (13-294)	0.012	56	72	0.041
Chocolate confectionery	21 (2-81)	30 (2-104)	0.001	68	92	≤ 0.0001
Non-chocolate confectionery	10 (1-65)	14 (1-71)	ns	36	54	0.022
Cakes and pastries	25 (6-175)	36 (3-204)	ns	36	67	≤ 0.0001
Pure fruit juice	120 (35-750)	114 (25-618)	ns	40	59	0.016
Squash/cordials	101 (10-513)	144 (13-1000)	ns	38	62	0.001
Other fruit	82 (8-400)	91 (6-772)	ns	34	56	0.006
Potato crisps	14 (5-81)	19 (1-54)	ns	46	72	0.001
Soups and sauees	25 (4-150)	33 (4-250)	ns	51	68	0.021

[$]Reporting category derived as the ratio of energy intake to estimated basal metabolic rate where: under-reporters have a ratio <1.39 (boys) and <1.30 (girls); adequate reporters 1.39-2.24(boys) and 1.30-2.10 (girls); over-reporters have a ratio > 2.24 (boys) and > 2.10 (girls).

4.4 Discussion.

The ability to accurately estimate dietary intake represents one of the most significant limitations to any study that proposes to quantify nutrient intakes and requirements. This study has clearly identified that under-reporting dietary intake affects a significant number of young Dublin adolescents (39% (*n* 94) and 50% (*n* 93) at age 11 and 12 years, respectively). In this study, the most likely children to under-report dietary intake were those found to be the heaviest and the fattest, to report the least satisfaction with perceived body shape, to express a desire to be thinner and to have previously dieted. This aside, the reported energy intake and composition of the total group in the present study has not changed from that reported 10 years ago in the only previous assessment of dietary intakes among Irish children in which under-reporting was not considered (Hurson and Corish 1997).

Goldberg *et al* (1991) and Black *et al* (1991) suggested a screening of energy intake data of adult populations, calculating them as multiples of basal metabolic rate or physical activity levels, where a value below 1.27 x BMR is unacceptable as representative of habitual intake (FAO/WHO/UNU 1985). The range of physical activity levels used to validate reported energy intake in the present study was based on estimates made of the habitual 24h physical activity levels from data from studies of doubly labeled water and heart rate monitoring of children and adolescents (482 boys and 418 girls) with different lifestyles (Torun *et al* 1996). The lower value represents two times the coefficient of variation below the physical activity level corresponding to light habitual activity, and the higher value represents two times the coefficient of variation above the physical activity level for heavy habitual activity (Torun *et al* 1996). They follow the same fundamental principal of energy physiology (energy expenditure equals energy intake when in energy balance) as the cutoffs derived for adults (Goldberg *et al* 1991). But the latter are unsuitable for use among children since the energy costs of activities published for adults do not apply to those younger than 15 years (Torun 1983; Torun 1990).

Prior to the development of methods to accurately assess energy expenditure, and hence to derive energy requirements, it was assumed that the lower reported energy intakes among obese individuals compared to normal weight individuals were the result of a lower energy expenditure indicative of a sedentary lifestyle and that this led to the development of obesity. However, the advent of measuring energy expenditure, using doubly labeled water and heart rate monitoring techniques among free-living individuals has established that reported energy intakes among obese and non-obese adolescents are not representative of energy expenditure or energy requirements due to an almost inherent "systematic negative bias" (Bandini *et al* 1990; Livingstone *et al* 1992). As found in the present study, overweight individuals are more likely to under-report dietary intake than their normal-weight counterparts (Bandini *et al* 1990; Livingstone *et al* 1992). Dietary composition in the present study, in terms of the contributions made by macronutrients to energy, was comparable between each category of weight: underweight, normal weight and overweight. However, it is possible that even those overweight individuals who gave an adequate report of energy intake tended towards under estimating daily intake to such an extent as to mask any association of excess energy and fat intake with being overweight. Consequently, dietary intake data cannot be relied upon to assess the role of energy intake or energy expenditure in the development of obesity unless bias in reporting energy intake is accounted for (Bandini *et al* 1990).

The food diary method for recording daily dietary intake was chosen for this study as it was felt that it would be the least onerous for both the subjects and the investigator. Since underestimation may be partly attributable to forgetfulness and lack of compliance caused by the tedium of having to record food intakes on an almost hourly basis, the children in this study were not required to weigh their foods (Livingstone 1992). A combination of photographic food atlases (that used by the Irish National Nutrition Survey 1990 and by the Irish Universities Nutrition Alliance; Lee and Cunningham 1990; Harrington *et al* 2001*a*) offered a range of pictures and was used, where possible, to quantify the amount of food eaten. However, estimating the amount of food consumed requires that children can recognise and describe quantities in terms of proportions and whole units, have an adequately developed concept of time to express food intake in terms such as frequency and averages, and finally, that they can think abstractly about food while viewing generic food models of different volumes and dimensions or other tools such as food photographs (Livingstone and Robson 2000). The fact that food frequencies and portion sizes of children are not generally constant over time and that, in any case, it is most unlikely that they pay attention to frequencies and portion sizes when they are eating, further compound the problem (Livingstone and Robson 2000). Among young adolescents, their greater food requirements in combination with unstructured eating patterns and a significant degree of out-of-home eating suggests that under-reporting may be partly due to forgetfulness and lack of compliance with a demanding protocol (Torun *et al* 1996). This phenomenon is supported by the fact that there was no sex or SEC bias in mis-reporting dietary intake in the present study (Table 2).

Whether inadequate reports of dietary intake should be included in analysis is a contentious issue. Given that bias is predominately towards under-reporting dietary intake, including this group yields under-estimates of nutrient intakes. Measurements of intake are often used to determine the minimum intake of energy or a specific nutrient that is the requirement to maintain normal body function and health (Hill and Davies 2001). An under-estimation of the diet consumed will lead to false conclusions when attempting to establish the nutritional requirements of a certain group (Black *et al*

1993). Excluding under-reporters, however, does not take cognizance of the fact that in the present study approximately 30% of children, particularly girls (41% (*n* 53) at age 11 years and 38% (*n* 40) at age 12 years) attempt to diet. Indeed, studies have reported that up to 80% of teenage girls in Western communities diet at some point during adolescence (Schleimer 1983; Patton *et al* 1997). Therefore, excluding dieters may give a false measure of intake given the prevalence of body image concerns and frequency of dieting during adolescence. Moreover, dieting is not limited to the overweight groups in the present study although they were the most likely to under-report.

No method of dietary assessment is likely to be immune to misrepresentation of food intake by weight-concerned subjects (Livingstone *et al* 1992). Few studies, to date, have compared different methods of dietary assessment for validity of reported energy intake. Only one study has validated simultaneously energy intake by weighed dietary record and diet history with total energy expenditure by doubly labeled water (Livingstone *et al* 1992). Mean intakes assessed by diet history seemed more representative of habitual energy intake across the age range than weighed dietary record (Livingstone *et al* 1992), but diet history is not a standardized instrument and it only measures memory and perception of usual diet (Torun *et al* 1999). The potential to improve future assessments of dietary intake among groups of young adolescents exists through a characterization of those individuals who under-report and an increased awareness of the foods likely to be mis-represented. Those young adolescents who under-reported, compared to those who adequately reported dietary intake were significantly more likely to express dissatisfaction with their body shape and to desire a thinner shape. It is unlikely that the self-report questionnaire influenced under-reporting as it was conducted at the least one month before food diaries were kept. In addition, those who under-reported energy intake, were those who reported attempted weight loss. Furthermore, young adolescent schoolchildren who under-reported also had higher weight indices and a larger waist circumference than those who adequately or over-reported energy intake. In the absence of defined cut-offs of weight indices and circumferences among adolescents, identification of likely under-reporters of dietary intake may be made by posing a question to evaluate body image concerns. For example, a food intake assessment including figure line drawings, such as those employed in the present study, requiring the children to identify their self-perceived and preferred shapes will establish body shape preferences. Alternatively, enquiring about previous weight loss attempts will identify those children most likely to mis-represent dietary intake.

It could be reasonably assumed that the foods mis-represented by under-reporters (tables 5(a) and 5(b)) are those that are avoided by "dieters". Interestingly, the selective mis-representation of foods did not have an overall effect on reported percentage fat intake (ranging 37-39% at both 11 and 12 years) when compared to adequate reporters. The differences found between under-reporters and adequate reporters in percentage intakes of protein and sugar (at age 11 and 12 years) and starch and fibre (at age 12 years; Table 4) are probably the direct result of the differences found in the reported consumption of foodstuffs including fish, chocolate and non-chocolate confectionery and biscuits (Tables 5(a) and (b)). After exercise, eating less fatty and sugary foods are the most reported slimming practices; perhaps there is confusion among this age group as to what constitutes a "fatty" food.

The interpretation of energy composition, in terms of macronutrient intake, compared to reference nutrient intakes is difficult given that recommendations are largely extrapolated from infant and adult studies. For example, the reference for percentage fat covers a range from greater than 50% in infancy to approximately 30% in adulthood. Therefore, a reported fat intake of 37% at age 12 years could imply that the target of 30-35% at age 18 years is achievable. However, it is more likely that the current level of fat intake tracks into adulthood given the consistent reports of high fat intakes among Irish adults (Lee and Cunningham 1990; Harrington *et al* 2001*b*). The higher fibre density found among under-reporters at age 12 years (table 4) may have implications for micronutrient status as they approach puberty.

Energy intakes reported in this study (table 1) were lower than the current Irish recommended daily allowances of 8.73MJ/d and 7.64MJ/d for 10.5-11.5-year-old boys and girls, respectively, and 9.19MJ/d and 7.95MJ/d among boys and girls aged 11.5-12.5, respectively (Food Safety Authority of Ireland 1999). The recommended dietary allowances for Ireland follow the 1993 Nutrient and Energy Intakes for the European Community Recommendations. It expresses the energy requirements of children and adolescents aged 10-19 years in terms of average body weight and of a physical activity level of 1.65 for boys and 1.55 for girls aged 10-13 years (Scientific Committee for Food 1993; Food Safety Authority of Ireland 1999). The average body weights were determined from primary data sources from nine European countries comprising cross-sectional, mixed longitudinal studies published in the 1070s and 1980s and weighted by the size of population in each age and sex group before averaging (Scientific Committee for Food 1993). However, the body weights collected in the present study are much higher than those used in the recommendations (41.8kg *vs.* 33kg (boys) and 42.6kg *vs.* 34kg (girls) at age 11 years; 46.8kg *vs.* 36.5kg (boys) and 48.3kg *vs.* 37.5kg (girls) at age 12 years). In addition, the physical activity levels used in the recommendations are also much higher than the mean physical activity level of 1.44 and 1.50 among 11-year-old boys and girls and 1.34 and 1.38 among 12-year-old boys and girls in the present study. However, the body weights and physical activity levels of these Dublin schoolchildren compare well with those used to derive the dietary reference values used prior to the current recommendations (Department of Health 1991). This suggests that current recommendations may need to be re-evaluated in the context of current energy intakes, actual body weights and physical activity levels in the Republic of Ireland.

This study is the first in ten years to assess the energy and food intake of a group of Irish children. The only previous report of energy intakes among Irish children is that of the Irish National Nutrition Survey 1990 taken among an older group (Hurson and Corish 1997) than those included in the present study. A decade later, although a different dietary methodology was used, similar intakes are reported among the present group of 11 and 12 year old Dublin schoolchildren. A 5- and 2.5-fold increase in the prevalence of overweight has been found between this study and the Irish National Nutrition Survey 1990 (chapter 3.4) that cannot be explained by a change in reported energy intake. However, if under-reporting was prevalent among the Irish National Nutrition Survey 1990 cohort, which is possible given that they were an older group and under-reporting is known to increase with age (Livingstone and Robsobn 2000), actual energy composition may be masked. A comparison between adequate reporters only might give more of an insight. Or, perhaps more likely a reduction in energy expenditure may have occurred over the 10 years.

The findings of this study support the use of accompanying questionnaires with dietary assessment methods that determine satisfaction with body weight. Regardless of actual body weight status, a desire to be thinner is almost certain to produce an under-estimation of energy intake.

4.5 References.

Bandini LG, Schoeller DA, Cyr HN, Dietz WH (1990): validity of reported energy intake in obese and non-obese adolescents. *American Journal of Clinical Nutrition.* **52,** 421-425

Black AE, Goldberg GR, Jebb SA, Livingstone MBE, Cole TJ, Prentice AM (1991): Critical evaluation of energy intake data using fundamental principals of energy physiology: 2. Evaluating the results of published surveys. *European Journal of Clinical Nutrition.* **45,** 583-599

Black AE, Prentice AM, Goldberg GR, Jebb SA, Bingham SA, Livingstone MBE, Coward WA (1993): Measurements of total energy expenditure provide insights into the validity of dietary measurements of energy intake. *Journal of American Dietetic Association.* **93,** 572-579

Braam LAJM, Ocke MC, Bueno-de-Mesquita HB, Seidell JC (1998): Determinants of obesity-related underreporting of energy intake. *American Journal of Epidemiology.* **147,** 1081-1086

Bray GA, Popkin BM (1998): Dietary fat intake does affect obesity! *American Journal of Clinical Nutrition.* **68,** 1157-1175

Dietz WH, Harting R (1985): Changes in height velocity of obese pre-adolescents during weight reduction. *American Journal of Diseases of Childhood.* **139,** 705-707

FAO/WHO/UNU (1985): *Energy and protein requirements.* WHO Technical Report Seriese 724. Geneva: World Health Organisation

Fisher JO, Johson RK, Lindquist C, Birch LL, Goran MI (2000): Influence of body composition on the accuracy of reported energy intake in children. *Obesity Research.* **8,** 597-603

Food Safety Authority of Ireland (1999): Children's energy and protein requirements. *Recommended Dietary Allowances for Ireland.* Pp 13-14; 16-17 Dublin: Food Safety Authority of Ireland

Goldberg GR, Black AE, Jebb SA, Cole TJ, Murgatroyd PR, Coward WA, Prentice AM (1991): Critical evaluation of energy intake data using fundamental principals of energy physiology: 1. Derivation of cut-off limits to identify under-recording. *European Journal of Clinical Nutrition.* **45,** 569-581

Harrington KE, Robson PJ, Kiely M, Livingstone MBE, Lambe J, Gibney MJ (2001*a*): The North/South Ireland food consumption survey: survey design and methodology. *Public Health Nutrition.* **4 (5A),** 1037-1042

Harrington KE, McGowan MJ, Kiely M, Robson RJ, Livingstone MBE, Morrissey PA, Gibney MJ (2001*b*): Macronutrient intakes and food sources in Irish adults: findings of the North/South Ireland Food Consumption Survey. *Public Health Nutrition.* **4 (5A),** 1051-1060

Hill RJ, Davies PSW (2001): The validity of self-reported energy intake as determined using the doubly labelled water technique. *British Journal of Nutrition.* **85,** 415-430

Hurson M, Corish C (1997): Evaluation of lifestyle, food consumption and nutrient intake patterns among Irish teenagers. *Irish Journal of Medical Science.* **166(4),** 225-230

Lee P, Cunningham K (1990): *The Irish National Nutrition Survey.* Dublin: Irish Nutrition and Dietetic Institute

Livingstone MBE, Prentice AM, Coward WA, Strain JJ, Black AE, Davies PSW, Stewart CM, McKenna PG, Whitehead RG (1992): Validation of estimates of energy intake by weighed dietary record and diet history in children and adolescents. *American Journal of Clinical Nutrition.* **56,** 29-35

Livingstone MBE (2000): Epidemiology of childhood obesity in Europe. *European Journal of Paediatrics.* **159**: [Suppl 1], S14-S34

Livingstone MBE, Robson PJ (2000): Measurement of dietary intake in children. *Proceedings of the Nutrition Society.* **59,** 279-293

Miller JZ, kimes T, Hui S, Andon MB, Johnston CC (1991): Nutrient intake variability in a paediatric population: implications for study design. *Journal of Nutrition.* **121,** 265-274

Nelson M, Black AE, Morris JA, Cole TJ (1989): Between- and within-subject variation in nutrient intake from infancy to old age: estimating the number of days required to rank dietary intakes with desired precision. *American Journal of Clinical Nutrition.* **50,** 155-167

Patton GC, Carlin JB, Shao Q, Hibbert ME, Rosier M, Selzer R, Bowes G (1997): Adolescent dieting: healthy weight control or borderline eating disorder? *Journal of Child psychology and psychiatry.* **38(3),** 299-306

Pryer JA, Vrijheid M, Nichols R, Kiggins M, Elliott P (1997): Who are the 'low energy reporters' in the dietary and nutrition survey of the British adults? *International Journal of Epidemiology.* **26,** 146-153

Rolland-Cachera M-F, Bellisle F, Deheeger M (2000): Nutritional status and food intake in adolescents living in Western Europe. *European Journal of Clinical Nutrition.* **54,** Suppl 1, S41-S46

Schleimer K (1983): Dieting in teenage schoolgirls. *Acta paediatrica Scandinavica (supp)* **312**

Schofield WN (1985): Predicting basal metabolic rate, new standards and review of previous work. *Human Nutrition and Dietetics.* **39C,** Suppl 1, 5-41

Scientific Committee for Food, Commission of the European Communities (1993): Nutrient and energy intakes for the European Community, *Reports of the Scientific*

Committee for Food, 31st series. Luxembourg: Office for Official Publications of the European Commitees

Strain JJ, Robson PJ, Livingstone MBE, Primrose ED, Savage JM, Cran GW, Boreham CAG (1994): Estimates of food and macronutrient intake in a random sample of Northern Ireland adolescents. *British Journal of Nutrition.* **72,** 343-352

Torun B (1983): Inaccuracy of applying expenditure rates of adults to children. *American Journal of Clinical Nutrition.* **38,** 813-814

Torun B 91990): Energy cost of various physical activities in healthy children. In: *Activity, energy expenditure and energy requirements of infants and children,* eds Schrurch B & Scrimshaw NS, pp 139-183. Lausanne: International Dietary Energy Consultancy Group

Torun B, Davies PSW, Livingstone MBE, Paolisso M, Sackett R, Spurr GB (1996): Energy requirements and dietary energy recommendations for children and adolescents 1 to 18 years old. *European Journal of Clinical Nutrition.* **50,** Suppl.1, S37-S81

Wahl R (1999): Nutrition in the adolescent. P*ediatric Annals.* **28 (2),** 107-111

Chapter 5

Dietary factors and body image concerns associated with iron and folate status among young Dublin adolescents.

5.1 Introduction.

Adolescence is a period that involves growth and development which occurs through a complex interaction of genetic instructions, hormones and environmental influences, most of them dietary in origin (Lachance 1998). Micronutrients are essential for growth and development, utilisation of macronutrients, maintenance of adequate defences against infectious diseases and for many other metabolic and physiological functions (WHO 1996). The data upon which the recommendations for adolescent nutrient 'needs' are based is scanty (Olmedilla and Granado 2000). They are usually obtained by interpolating or extrapolating data collected in adults and children, rather than on actual experimental data (Dwyer 1981; Dwyer 1996).

It is ten years since the Irish National Nutrition Survey 1990 reported that the diet of Irish teenage boys and girls met with nutritional recommendations except for iron and folate intakes which fell below recommended standards (aged 12-14 and 15-18 years; Hurson and Corish 1997). Young adolescent boys and girls of Western civilisation are frequently reported to have inadequate intakes of calcium, magnesium, iron, zinc, vitamin A, riboflavin and folate when habitual intakes are compared to recommended daily allowances (McNulty *et al* 1996, Doyle *et al* 1994, Nelson *et al* 1993).

A poor iron status is associated with iron deficiency and iron deficiency anaemia which have been related to poor school performance (Nelson 1996). Iron needs are increased in adolescence to maintain body stores and haemoglobin concentration during growth. Boys increase their muscle mass and blood volume more rapidly than girls do, but although girls require less iron for growth they have increased iron needs due to menstrual losses (Olmedilla and Granado 2000). Low iron stores have been reported among young adolescents which included 40% of a group of Sligo adolescents (30 boys and 51 girls aged 14.5 to 18.5 years; Armstrong 1989); 11% of boys and 21% of girls aged 13-14 years from Norwich (Southon *et al* 1993); and 8% of boys and 28% of girls aged 12-13 years from London (Doyle *et al* 1994).

Folate deficiency can arise as a result of low dietary intake and increased demands during growth periods, such as puberty (Krishnaswamy and Nair 2001). An adequate folate status is necessary to reduce the risk of neural tube defects and hyperhomocysteinemia. The link between neural tube defects and low serum folate is well documented and is an obvious concern for girls in their late teens (Scott and Kirke 1990). Hyperhomocysteinemia has been implicated in mental retardation in children, developmental defects, occlusive disorders, and osteoporosis and there is evidence that it is an independent risk factor for ischaemic heart disease (Krishnaswamy and Nair 2001; Wald *et al* 1998). There are few studies that report the prevalence of folate deficiency among children and adolescents and, to date, none exist in Ireland. An analysis of serum folate among 12-13-year-old schoolchildren of inner city London found none of the subjects fell below the lower limit of 7.0nmol/L (Doyle *et al* 1994).

It has been reported that many schoolchildren, particularly in less affluent areas, are eating poor diets (Doyle *et al* 1994). The observation of a low intake of micronutrients can also result from dietary reporting processes (including underreporting energy intake) and preoccupation with body weight (Livingstone and Robson 2000; Ryan *et al* 1997).

The purpose of this study was to estimate the iron and folate status and the prevalence of deficiency anaemias among young Dublin schoolchildren from different socio-economic backgrounds in a one-year follow-up study. Since body image concerns may provoke the under-reporting of habitual intake and hence misrepresentation of reported nutrient intake, iron and folate status were measured from capillary samples. The association between reported food intakes and haematinic status was investigated. This relationship may have implications for public health initiatives.

5.2 Subjects and Methods.

5.2.1 Subjects.

Subjects were recruited for this study through Dublin city primary schools as described in chapters 2.1 and 2.2. This study represents a random sample of 55% of the children recruited (*n* 239, 110 boys, 129 girls, mean age 11 years), controlled equally for sex and schooltype who completed a questionnaire, had measurements of anthropometry taken and recorded dietary intake. One year later 77% of this random sample (*n* 185, 79 boys, 106 girls, mean age 12 years) repeated the study in a one-year follow-up.

5.2.2 Socio-economic class.

Social background was classified according to the highest classed earner within a household as described in chapter 4.2.2.

5.2.3 Anthropometry.

Measurements were taken to assess body mass in terms of actual relative weight, body mass index and body fat distribution as described in chapter and sub-sections 2.6.

5.2.4 Dietary intake.

Each subject kept a food diary for two days on two separate occasions as described in chapter and subsections 2.8.

Supplement use was reported in a interview assisted questionnaire described in chapters 2.5.2 and 2.5.3. The quantity of supplemental iron and folic acid was calculated as the amount per day. Intakes of red meat, fish, ham, pork, bacon and poultry per day were combined to give the mean intake of meat per day and to estimate the intake of haem iron. Reported folic acid intake was quantified as the amount per gram of fortified food (breakfast cereal and milk) consumed. The subjects could not reliably report the brand of bread eaten and this was therefore omitted from estimations of folic acid intake. All nutrient data reported in this study are based on dietary information alone (including fortified foods) and do not include nutrient intake estimates from supplement sources except where stated.

Adequacy of iron and folate intake was determined by comparison with reference nutrient intakes and estimated average requirements (Department of Health 1991).

5.2.5 Pubertal stage of maturation.

Identification of early and late maturers was made using growth data as described in chapter 3.2.5.

5.2.6 Body image concerns.

Satisfaction with perceived body shape and slimming practices were reported using the questionnaire described in chapter 2.7.

5.2.7 Prevalence of anaemia.

Haematinic status of iron and folate was determined from capillary blood samples collected and determined as described in chapter and sub-sections 2.9. a low iron store was identified as a serum ferritin concentration $\leq$ 12μg/L, a borderline iron store as 12.01-20μg/L, and sufficient iron sores as $\geq$ 20μg/L. Iron deficiency anaemia was identified as a low iron store with low haemoglobin ($\leq$11.5 and $\leq$13.0g/dL in 11- and 12-year-old boys respectively, and $\leq$11.5 and $\leq$12.0g/dL in 11- and 12-year-old girls respectively; Dallman 1977). A soluble serum transferring receptor concentration of greater than 28.1nmol/L was indicative of iron deficiency anaemia (Allan *et al* 1998).

Low folate intakes were identified as a red cell folate ≤100μg/L, borderline folate stores as 100.01-150μg/L, and sufficient stores as ≥150μg/L (Suaberlich 1974).

5.2.8 Data management and statistical analysis.

Each food diary was coded using food codes described in chapter 2.8.5 and analysed using WISP, version 1.26, a nutritional package for Windows (Tinuviel Software). Comparisons for the total group, sex and social class were made between year 1 (1999) and year 2 (2000) using the following statistics as appropriate; Wilcoxon Signed Rank, paired t-test. Variables were analysed according to sex, SEC, body weight category, pubertal stage, and tissue stores of iron and folate using χ^2 test, Mann-Whitney, independent t-test and one-way ANOVA, as appropriate. Significant differences found between groups using one-way ANOVA were identified by the *post hoc* tests LSD if normally distributed and Tamhane comparisons if not. Correlations between iron and folate status and nutrient and food intake was assessed using Pearson's or Spearman's correlation as appropriate. The prediction of iron or folate status from independent variables of food intake, demographic and body image indices were analysed from multivariate logistic regression models. A significant difference was indicated by a p value ≤ 0.05.

5.3 Results.

Eighty- percent (n 97) of SEC1 attended FP schools whereas 72% (n 36) of SEC2 and 98% (n 62) of SEC3 attended NFP schools. Therefore, schooltype is used as a proxy for SEC. The mean (standard deviation) concentrations of haematinic variables are shown in table 1 according to age and sex. Tissue stores of iron and folate were comparable between the sexes except at age 12 years where boys had significantly greater folate stores than girls (605.1 (218.1) μg/L vs. 494.8 (236.2)μg/L, $p \leq 0.05$; table 1).

The prevalence of low iron stores was comparable among boys (7% (*n* 6)) and girls (8% (*n* 8)) at age 11 years. At age 12 years, girls were more likely than boys to have a low iron store (15% (*n* 12) *vs.* 3% (*n* 2), $p = 0.054$). At age 11 years, one girl (1%) was found to have a low folate store. At age 12-years-old all subjects were found to have sufficient folate stores (results not shown).

Iron deficiency anaemia based on a low serum ferritin concentration (≤ 12μg/L) with a low haemoglobin concentration was found in one girl (1%) at age 11-years-old. This girl reported menarche. At age 12 years, iron deficiency anaemia had increased in prevalence and was found in both boys (1%, *n* 1) and girls (4%, *n* 4). Of the girls with iron deficiency anaemia one reported menarche and this was not the same girl found to be anaemic the previous year (results not shown).

Iron deficiency anaemia based on serum transferrin receptor concentrations (≥28.1nmol/L) was found to be prevalent among boys (9%, *n* 7) and girls (8%, *n* 9). Of the subjects identified as having iron deficiency anaemia based on the presence of low serum ferritin and haemaglobin concentrations, one had a serum transferrin receptor concentration ≥28.1nmol/L. Serum transferrin receptor concentration was comparable between the quartiles of serum ferritin concentrations at age 12 years.

Thirty-two percent (*n* 78) of subjects reported taking nutrient supplements at the age of 11 years. Of the supplement users, 50% (*n* 39) reported taking a daily supplement. Reported use of supplements was comparable between the sexes but not between SEC where FP subjects were more likely than NFP subjects to report use (49% (*n* 53) *vs*. 22% (*n* 25), $p \leq 0.05$). At age 12 years, 33% (*n* 61) of subjects reported taking nutrient supplements. Of the supplement users, 67% (*n* 41) reported taking a daily supplement. Again the sexes were comparable in use but FP subjects were more likely than NFP subjects to take supplements (44% (*n* 38) *vs*. 26% (*n* 23), $p \leq 0.05$). Supplements containing iron were reported to be taken by 8% (*n* 19) of 11-year-olds and 9% (*n* 17) of 12-year-olds and supplements containing folic acid were reported by 4% (*n* 9) of 11-year-olds and 6% (*n* 11) of 12-year-olds.

The reported median and range of vitamin and mineral intakes per day for the total group are shown in table 2 according to age and sex. At age 11- and 12-years-old the reported intake of total iron and total folate fell below the reference nutrient intakes for boys (11.3mg/d iron and 200μg/d folate) and girls (14.8mg/d iron and 200μg/d folate; Department of Health 1991). At 11 years old, girls were more likely than boys to respectively report intakes that were below the estimated average requirements (Department of Health 1991) for total iron (85% (*n* 109) *vs*. 43% (*n* 47), $p \leq 0.05$) and total folate (34% (*n* 44) *vs*. 29% (*n* 32), *ns*). Similarly, at age 12 years, girls were more likely than boys to respectively report intakes below the estimated average requirements for total iron (83% (*n* 88) *vs*. 35% (*n* 28), $p \leq 0.05$) and total folate (47% (*n* 50) *vs*. 27% (*n* 21), $p \leq 0.05$). Those who reported intakes below the estimated average requirements for iron were likely to be classified as under-reporters of habitual dietary intake at age 11 years (48%, *n* 75) and at age 12 years (60%, *n* 70). Similarly, those who reported total folate intakes below the estimated average requirements were more likely to be under-reporters at age 11 years (60%, *n* 45) and 12 years (66%, *n* 47).

Subjects in the lowest quartiles for iron and folate stores were compared with those in the highest quartiles with respect to demographics, body weight and body image concerns (table 3). Body image concerns and weight loss attempts were not associated with iron or folate status whereas being of a less advantaged SEC proportionately were the most likely to occupy the group with the lowest tissue status. Reported menarche among girls was comparable between low and high quartiles of iron and folate stores. Predictors of iron and folate status, including dietary and body image factors, were assessed by multivariate linear regression models and are shown in tables 4(a) and 4(b). The predictors of iron status that emerged were relatively weak. Socio-economic background emerged as a more important predictor of iron status among girls than dietary factors at age 11- and 12-years-old but no predictors of iron status emerged for boys (tables 4(a) and 4(b)). Fortification of foodstuffs was found to consistently increase the odds of occupying the group of the highest folate tissue stores except among 12-year-old boys where, again, no predictors emerged from the multivariate linear regression model.

Data for the median daily intakes (for consumers only) of those foods which, among 47 different categories of foodstuffs/drinks examined, emerged as being eaten differently in terms of the quantities consumed (g/d), and of those foods which emerged as being eaten by different proportions (% consumers) of subjects in low and high quartiles of iron and folate status, are shown in tables 5 and 6 according to age. The overall proportion of subjects habitually consuming fortified breakfast cereals was comparable among boys and girls at age 11 years (76%, *n* 84 *vs.* 73%, *n* 94) and 12 years (75%, *n* 59) *vs.* 69%, *n* 73).

Table 1: Mean (standard deviation) concentrations of haematinic variables measured from capillary samples of young Dublin adolescents schoolchildren[$] according to age and sex in a one-year follow-up study.

Haematinic Variable	Age 11 years			Age 12 years		
	Total group	Boys	Girls	Total group	Boys	Girls
Red Blood Cells (x 10^6/µL)	4.3 (0.8)	4.3 (0.8)	4.3 (0.8)	4.6 (0.6)	4.6 (0.7)	4.7 (0.6)
Mean Corpuscular Volume (*f*L)	84.5 (3.3)	83.8 (2.9)	85.1 (3.6)*	83.4 (4.3)	82.5 (3.9)	84.0 (4.5)*
Mean Corpuscular Haemoglobin Concentration (g/dL)	36.1 (3.7)	36.4 (4.6)	35.8 (2.8)	33.8 (2.1)	34.2 (2.5)	33.5 (1.7)
Haemoglobin (g/dL)	12.8 (2.1)	12.8 (2.0)	12.6 (2.2)	13.1 (1.8)	13.0 (2.0)	13.1 (1.6)
Serum ferritin (µg/ml)	56.3 (47.7)	58.1 (48.9)	54.9 (46.9)	51.4 (36.9)	53.7 (39.6)	49.6 (34.7)
Soluble Serum Transferrin Receptor (nmol/L)	N/a	N/a	N/a	21.8 (6.8)	22.9 (6.4)	20.8 (7.1)
Red Cell Folate (µg/ml)	485.9 (275.7)	499.5 (270.9)	474.2 (280.3)	538.3 (234.8)	605.1 (218.1)	494.8 (236.2)*

[$]At age 11 years adequate capillary samples were collected of full blood count (*n* 195, 85 boys, 100 girls), serum ferritin (*n* 193, 87 boys, 106 girls) and red cell folate (*n* 215, 99 boys, 116 girls); At age 12 years adequate capillary samples were collected of full blood count (*n* 142, 58 boys, 84 girls), serum ferritin (*n* 145, 65 boys, 80 girls) and red cell folate (*n* 137, 54 boys, 83 girls) and soluble serum transferrin receptor (*n* 128, 60 boys, 68 girls).
*Significantly different from boys of the same age.

Table 2: Mean (standard deviation) of reported energy intake and the ratio of energy intake to estimated basal metabolic rate and the median (range) of reported vitamin and mineral intakes of young Dublin adolescent schoolchildren according to age and sex in a one-year follow-up study.

Variable	Total group		Boys		Girls	
	Age 11y (*n* 239) Median (range)	Age 12y (*n* 185) Median (range)	Age 11y (*n* 110) Median (range)	Age 12y (*n* 79) Median (range)	Age 11y (*n* 129) Median (range)	Age 12y (n 106) Median (range)
Energy (MJ/d)	8.0 (2.1)	8.0 (2.4)	8.3 (2.2)	8.4 (2.3)	7.8 (2.0)	7.7 (2.4)*
EI:BMR$_{est}$	1.47 (0.4)	1.33 (0.2)	1.44 (0.4)	1.34 (0.2)	1.50 (0.4)	1.38 (0.4)
Iron (mg/d)	8.9 (2.9-29.8)	8.8 (3.4-21.9)	9.3 (2.9-21.1)	9.8 (3.7-21.9)	8.6 (4.0-29.8)*	8.0 (3.4-20.5)*
Haem iron (mg/d)	0.6 (0.03-2.9)	0.7 (0.02-2.5)	0.6 (0.1-2.9)	0.8 (0.1-2.5)†	0.6 (0.03-2.8)	0.7 (0.02-1.6)
Non-haem iron (mg/d)	8.4 (2.5-29.6)	7.9 (3.2-20.9)	8.7 (2.5-19.3)	9.1 (3.2-20.9)	7.9 (3.4-29.6)*	7.5 (3.3-20.1)*
Calcium (mg/d)	729.0 (157.0-1912.0)	697.0 (182.0-1729.0)	754.0 (157.0-1858.0)	773.0 (182.0-1729.0)	713.0 (243.0-1912.0)	630.0 (226.0-1617.0)
Zinc (mg/d)	6.5 (1.8-17.0)	6.5 (1.7-18.5)	6.7 (2.0-17.0)	7.5 (1.7-18.5)	6.2 (1.8-14.7)	6.2 (2.6-13.9)*
Total Folate (µg/d)	188.0 (43.0-994.0)	167.0 (54.0-551.0)	196.5 (43.0-425.0)	188.0 (61.0-551.0)	177.0 (47.0-994.0)	157.0 (54.0-390.0)*
Folic acid (µg/d)	100.0 (3.57-531.7)	89.3 (10.7-800.8)	125.0 (10.7-486.7)	107.1 (10.7-800.8)	75.0 (3.6-531.7)*	82.1 (21.4-583.1)*
Vitamin C (mg/d)	76.0 (6.0-281.0)	62.0 (7.0-462.0)	66.0 (6.0-259.0)	49.0 (8.0-462.0)	86.0 (10.0-281.0)*	73.0 (7.0-260.0)*
Vitamin A r.e. (µg/d)	580.0 (34.0-3866.0)	507.0 (26.0-2124.0)	628.5 (111.0-1788.0)	509.0 (26.0-1679.0)	556.0 (34.0-3866.0)*	482.5 (28.0-2124.0)
Vitamin D (µg/d)	1.5 (0.1-9.9)	1.5 (0.0-14.4)	1.7 (0.1-6.2)	1.6 (0.2-9.2)	1.5 (0.1-9.9)	1.5 (0.0-14.4)
Thiamin (µg/MJ)	173.1 (73.7-2205.0)	168.7 (70.1-505.2)	178.2 (73.7-2205.0)	171.2 (70.1-505.2)	162.5 (90.9-1341.4)	167.7 (97.9-381.6)
Riboflavin (mg/d)	1.5 (0.3-7.3)	1.4 (0.4-3.6)	1.6 (0.3-4.0)	1.7 (0.5-3.6)	1.4 (0.4-7.3)*	1.3 (0.4-3.4)*
Niacin (mg/MJ)	3.7 (2.1-16.2)	3.6 (2.0-7.8)	3.9 (2.1-5.9)	3.8 (2.0-6.3)	3.5 (2.1-16.2)*	3.6 (2.2-7.8)
Vitamin B6 (µg/g protein)	28.4 (10.6-225.2)	28.1 (14.8-73.5)	28.2 (13.2-225.2)	27.9 (16.8-73.5)	28.4 (10.6-75.8)	28.2 (14.8-66.3)
Vitamin B12 (µg/d)	3.1 (0.0-9.6)	3.0 (0.6-8.6)	3.2 (0.4-9.0)	3.3 (0.6-8.6)	2.9 (0.0-9.6)*	2.8 (0.7-8.6)*

EI:BMR$_{est}$= energy intake to estimated basal metabolic rate; *Significantly different from the median intake of boys within the same age category (Mann Whitney, $P \leq 0.05$); † Significantly different from 11-year-old boys (Wicoxin, $P \leq 0.05$)

Table 3: Demographics, actual relative weight categories, and body image concerns, reported by young Dublin adolescent schoolchildren in the lowest and the highest quartiles of iron and folate stores measured from capillary samples of serum ferritin and red cell folate in a one-year follow-up study according to age.

	Age 11 years				Age 12 years			
	Iron stores		Folate stores		Iron stores		Folate stores	
	Low	High	Low	High	Low	High	Low	High
	SF<23µg/L	SF>78µg/L	RCF<341µg/L	RCF>540µg/L	SF<30µg/L	SF>63µg/L	RCF<431µg/L	RCF>609µg/L
	(*n* 50)	(*n* 47)	(*n* 53)	(*n* 53)	(*n* 38)	(*n* 36)	(*n* 34)	(*n* 33)
	% (*n*)	% (*n*)	% (*n*)	% (*n*)	% (*n*)	% (*n*)	% (*n*)	% (*n*)
Male	44 (22)	45 (21)	45 (24)	45 (24)	45 (17)	44 (16)	38 (13)	39 (13)
Female	56 (28)	55 (26)	55 (29)	55 (29)	55 (21)	56 (20)	62 (21)	61 (20)
Fee-paying	46 (23)	55 (26)	50 (23)	50 (23)	32 (12)	56 (20)*	29 (10)	61 (20)*
Non-fee-paying	54 (27)	45 (21)	50 (30)	50 (30)	68 (26)	44 (16)*	71 (24)	39 (13)*
Less than EAR for total iron	72 (36)	62 (29)	74 (39)	62 (33)	53 (20)	67 (24)	68 (23)	73 (24)
Less than EAR for total folate	32 (16)	30 (14)	45 (24)	25 (13)*	34 (13)	42 (15)	56 (19)	33 (11)
Taking vitamin/mineral supplements	37 (17)	39 (16)	28 (13)	39 (19)	28 (9)	41 (13)	17 (5)	47 (14)*
Actual relative weight: Underweight	26 (13)	21 (10)	34 (18)	30 (16)	26 (10)	22 (8)	32 (11)	33 (11)
Normal weight	46 (23)	55 (26)	45 (24)	49 (26)	53 (20)	47 (17)	50 (17)	49 (16)
Overweight	28 (14)	23 (11)	21 (11)	21 (11)	21 (8)	31 (11)	18 (6)	18 (6)
Satisfied with body shape	62 (31)	75 (35)	65 (34)	60 (32)	61 (23)	67 (22)	50 (17)	60 (18)
Expresses desire to be thinner	26 (13)	19 (9)	27 (14)	25 (13)	32 (12)	27 (9)	41 (14)	30 (9)
Has tried to previously lose weight	31 (15)	26 (12)	33 (17)	20 (10)	21 (8)	39 (12)	32 (11)	29 (8)
Under-reported habitual dietary intake	40 (20)	32 (15)	51 (27)	38 (20)	34 (13)	61 (22)	56 (19)	61 (20)

SF=serum ferritin; RCF=red cell folate; *Significantly different to group with low tissue stores, $p \leq 0.05$

Table 4(a): Predictors of iron status among young Dublin adolescent schoolgirls at (a) age 11 years and (b) age 12 years.

Predictor	B	Odds ratio	*P* value	Confidence interval	
				Lower	Upper
(a) age 11 years					
Schooltype	1.270	3.562	0.03	1.128	11.250
(b) age 12 years					
Schooltype	2.864	17.524	0.009	2.046	150.087
Non-haem iron (mg/d)	-0.488	0.614	0.017	0.411	0.917

Schooltype=fee-paying and non-fee-paying.
Variables entered on step 1: Schooltype; Reported weight loss attempt; and intakes of Haem iron (mg/d), Non-haem iron (mg/d), Calcium (mg/d), Energy (MJ/d), Vitamin C (mg/d), and Fibre/1000kcals

Table 4(b): Predictors of folate status among young Dublin adolescent schoolboys at (a) age 11 years and schoolgirls at (b) age 11 years and (c) age 12 years.

Predictor	B	Odds ratio	*P* value	Confidence interval	
				Lower	Upper
(a) Boys age 11 years					
Added folic acid	0.012	1.012	0.044	1.000	1.025
(b)Girls age 11 years					
Added folic acid	0.020	1.020	0.025	1.003	1.038
(c)Girls age 12 years					
Added folic acid	0.029	1.029	0.040	1.001	1.057

Variables entered on step 1: Socio-economic class; Reported weight loss attempt; and intakes of Energy (MJ/d), Fibre/1000kcals, Total Folate (μg/d), and added folic acid (μg/d)

Table 5(a): Median and range of reported intakes (grams per day) among consumers only, of foodstuffs eaten in significantly different quantities by young Dublin adolescent schoolchildren in the lowest (serum ferritin < 23µg/d) and the highest (serum ferritin > 78µg/d) quartiles of measured iron status at age 11 years; and the proportions (%) of these and other significant foodstuffs eaten by these groups.

	Food intakes (g/d) among consumers only			Percentage consuming foodstuffs		
	Low iron stores	High iron stores		Low iron stores	High iron stores	
	Median (range)	Median (range)	P value	%	%	P value
Meat, fish and poultry	44.0 (6.0-230.0)	83.0 (8.0-238.0	0.009	100(50)	100 (47)	ns
Red meat	30.0 (7.0-133.0)	50.0 (11.0-150.0)	ns	18 (9)	40 (19)	0.024
Pork, ham and bacon	25.0 (6.0-94.0)	38.0 (4.0-120.0)	ns	42 (21)	79 (37)	≤0.001
Mixed dishes	63.0 (13.0-366.0)	50.0 (15.0-175.0)	ns	34 (17)	66 (31)	0.002
White bread	50.0 (13.0-117.0)	64.0 (13.0-218.0)	0.005	86 (43)	96 (45)	ns
Squash/eordials	109.5 (20.0-533.0)	150.0 (9.0-621.0)	ns	60 (30)	81 (38)	0.029

ns=Not Significant

Table 5(b): Median and range of reported intakes (grams per day) among consumers only, of foodstuffs eaten in significantly different quantities by young Dublin adolescent schoolchildren in the lowest (serum ferritin < 30µg/d) and the highest (serum ferritin > 63µg/d) quartiles of measured iron status at age 12 years; and the proportions (%) of these and other significant foodstuffs eaten by these groups.

	Food intakes (g/d) among consumers only			Percentage consuming foodstuffs		
	Low iron stores	High iron stores		Low iron stores	High iron stores	
	Median (range)	Median (range)	p value	%	%	p value
Processed meats	38.0 (9.0-95.0)	33.0 (8.0-90.0)	ns	71 (27)	39 (14)	0.010
Brown bread	14.5 (9.0-40.0)	26.0 (8.0-133.0)	ns	16 (6)	36 (13)	0.041
White bread	55.0 (13.0-190.0)	47.0 (8.0-145.0)	ns	97 (37)	83 (30)	0.046
Other vegetables	32.0 (5.0-50.0)	10.5 (5.0-41.0)	0.017	47 (18)	44 (16)	ns
Cream	15.0 (3.0-60.0)	---	ns	13 (5)	---	0.031
Non-chocolate confectionery	35.0 (3.0-71.0)	11.0 (1.0-33.0)	0.01	53 (20)	47 (17)	ns
Potato crisps	22.0 (7.0-56.0)	14.0 (1.0-44.0)	0.004	71 (27)	53 (19)	ns

ns=Not Significant

Table 6(a): Median and range of reported intakes (grams per day) among consumers only of foodstuffs eaten in significantly different quantities by young Dublin adolescent schoolchildren in the lowest (red cell folate < 341μg/d) and the highest (red cell folate > 540μg/d) quartiles of measured folate status at age 11 years; and the proportions (%) of these and other significant foodstuffs eaten by these groups.

	Food intakes (g/d) among consumers only			Percentage consuming foodstuffs		
	Low folate stores	High folate stores		Low folate stores	High folate stores	
	Median (range)	Median (range)	p value	%	%	p value
Fortified breakfast cereals	18.0 (1.0-48.0)	30.5 (3.0-83.0)	0.003	66 (35)	87 (46)	0.021
Low fat and fortified milks	181.0 (21.0-256.0)	232.0 (13.0-629.0)	0.013	17 (9)	43 (23)	0.005
Meat, fish and poultry	79.0 (6.0-204.0)	59.0 (4.0-161.0)	0.033	100 (53)	100 (53)	ns
Mixed dishes	60.0 (15.0-267.0)	60.0 (11.0-190.0)	ns	40 (21)	60 (32)	0.026
Poultry	36.5 (4.0-133.0)	30.0 (5.0-75.0)	0.032	60 (34)	60 (34)	ns
Eggs and egg dishes	30.0 (15.0-165.0)	23.0 (8.0-60.0)	0.043	36 (19)	42 (22)	ns
Fish and fish dishes	29.0 (8.0-94.0)	25.0 (11.0-90.0)	ns	38 (20)	17 (9)	0.028
Squash/cordials	100.0 (13.0-588.0)	122.0 (13.0-501.0)	ns	79 (42)	62 (33)	0.043
Tea	150.0 (50.0-450.0)	300.0 (50.0-3100.0)	0.045	32 (17)	32 (17)	ns

ns=Not Significant

Table 6(b): Median and range of reported intakes (grams per day) among consumers only of foodstuffs eaten in significantly different quantities by young Dublin adolescent schoolchildren in the lowest (red cell folate < 431μg/d) and the highest (red cell folate > 609μg/d) quartiles of measured folate status at age 12 years; and the proportions (%) of these and other significant foodstuffs eaten by these groups.

	Food intakes (g/d) among consumers only			Percentage consuming foodstuffs		
	Low folate stores	High folate stores		Low folate stores	High folate stores	
	Median (range)	Mcdian (range)	p value	%	%	p value
Fortified breakfast cereal	18.0 (7.0-58.0)	30.0 (4.0-93.0)	0.023	62 (21)	79 (26)	ns
Low fat and fortified milk	157.0 (75.0-628.0)	175.0 (38.0-647.0)	ns	15 (5)	46 (15)	0.008
Meat, fish and poultry	90.0 (9.0-275.0)	67.0 (6.0-131.0)	0.044	100 (34)	100 (33)	ns
Ham, pork and bacon	43.0 (7.0-179.0)	25.0 (6.0-130.0)	0.041	59 (20)	46 (15)	ns
White bread	71.0 (13.0-189.0)	43.0 (8.0-190.0)	ns	97 (33)	76 (25)	0.013
Other bread	24.5 (5.0-56.0)	50.0 (13.0-118.0)	0.041	29 (10)	33 (11)	ns
Other vegetables	30.0 (8.0-38.0)	35.0 (1.0-60.0)	ns	27 (9)	52 (17)	0.046
Other fruit (not citrus)	79.0 (19.0-155.0)	150.0 950.0-400.0)	0.010	32 (11)	36 (12)	ns
Tea	162.5 (38.0-600.0)	225.0 (75.0-200.0)	ns	53 (18)	21 (7)	0.011
Sugar, syrups and preserves	5.0 (1.0-21.0)	7.5 (1.0-31.0)	0.020	62 (21)	73 (24)	ns
Chocolate confectionery	28.0 (3.0-96.0)	17.0 (2.0-73.0)	0.023	85 (29)	64 (21)	0.039
Potato crisps	24.0 (7.0-56.0)	10.0 (5.0-44.0)	0.013	68 (23)	55 (18)	ns

ns=Not Significant

5.4 Discussion.

Reported dietary intakes of total iron and folate would seem to indicate that young Dublin adolescents are not consuming enough nutrient to maintain tissue stores (table 2). However, actual estimation of haematinic stores found that the prevalence of iron deficiency anaemia is low among both 11- and 12-year-olds (<1% *vs.* 3%). Furthermore, both iron and folate stores are adequate except in a small minority. Under-reporting of habitual dietary intake was found to be responsible for the majority of intakes reported to be below the estimated average requirements but had no association with actual tissue stores.

The reference nutrient intake for a nutrient overestimates the prevalence of inadequacy as, by definition, it is the mean requirement of the population plus two standard deviations and is assumed to meet the dietary requirements of nearly all (97.5%) the healthy people in that population (Department of Health 1991). Therefore, individuals meeting the reference nutrient intake can be regarded as having an intake that substantially meets their nutrient needs. The actual requirement (estimated average requirement) has been used among adult populations as a cut-off to assess the prevalence of inadequacy of dietary intake (Carriquiry 1999). The estimated average requirement is the daily intake value that is estimated to meet the requirements as defined by a specified indicator of adequacy in 50% of a life-stage or gender group. Notwithstanding, reported intakes were still substantially below the estimated average requirement (Department of Health 1991).

Under-reporting dietary intake was prevalent among those who reported intakes of iron and folate below the estimated average requirement. Conceivably, under-reporters of energy intake would be expected to consume less food and therefore have inadequate intakes of nutrients as a result. Estimating the amount of food consumed is a complex cognitive task, even for adults (Livingstone and Robson 2000). The problem is compounded by the fact that food frequencies and portion sizes of children are not constant over time and, in any case, it is most unlikely that they pay attention to these when they are eating (Livingstone and Robson 2000). With respect to some foods, e.g. bread, the children could not state whether it was a fortified product, simply whether it was brown or white. A lower knowledge of foods and their preparation among children is recognised as causing incorrect identification of foods (Emmons and Hayes 1973). A request to provide the packaging while recording intake data in food diaries was achieved by only 3% (*n* 6) and 2% (*n* 3) of subjects at ages 11 and 12 years respectively.

The variance ratio in nutrient intake (the ratio of within:between-subject variances) indicates the ability of a dietary assessment to rank subjects in the distribution of intakes (Livingstone and Robson 2000; Miller *et al* 1991; Nelson *et al* 1989). In studies of nutrient intakes among children and adolescents the variance ratio for most nutrients is approximately twice that seen in adults (Miller *et al* 1991; Nelson *et al* 1989), with higher values consistently observed among girls compared to boys. As a result greater than 20 days of records are required to precisely measure vitamin intake. Random errors that could affect the precision of estimating nutrient intake should be minimised by the number of subjects included in the study (Bingham 1987). Unfortunately, such large numbers was an important time-limiting factor that determined the number of days over which dietary intake could be recorded.

The EI:BMR is a measure of habitual food intake (Torun *et al* 1996) and was discussed in detail in chapter 4.4. The reported EI:BMR in table 2 indicates that the food intakes are representative of habitual intake but the presence of under-reporters and over-reporters among these groups are likely to have extended the range of reported intakes, such that ranking of these subjects into the extremes of the distribution (e.g. quartiles of intake) may be invalid and result in biased conclusions. Therefore, the ability to rank subjects on the basis of actual tissue stores is an obvious advantage and, indeed, the prevalence of under-reporting was evenly distributed among quartiles.

Dieting and weight consciousness could also have contributed to observed low nutrient intakes (Livingstone and Robson 2000). Subjects who reported that they tried to lose weight at age 11 years (32%, *n* 73) and at age 12 years (33%, *n* 57) were shown to be more likely to under-report energy intake than subjects who have not tried to lose weight (chapter 4.4, table 2). Both boys and girls commonly reported eating less milk and meat as methods of losing body weight. However, dissatisfaction or concern about body weight was not found to differ between those with low compared to high tissue stores of either iron or folate. Among older adolescent girls (age 15 years) meat avoidance, reported as a slimming practice is thought to contribute to a low iron intake (Ryan et al 1997*b*). Also, a lack of knowledge about calcium requirements and the general perception that "milk is fattening" has contributed to observed low calcium intakes among 15-year-old Dublin schoolgirls (Ryan *et al* 1997*a*). However, actual tissue stores were not reported in either if these studies and therefore, whether low intakes affected stores is not known.

Although there are no comparative Irish studies of iron status from a similar age group to that in the present study (11 and 12 years), the prevalence of low iron stores reported is similar to that reported in the literature. In a study of 6 European countries the overall percentage of adolescent girls (*n* 1080, mean age 13.5 years) with low iron stores was 4.3% (ranging from <1% in the Netherlands to 11.5% in Italy; van de Vijver *et al* 1999). Nelson reported low iron stores among 1% of boys and 4% of girls aged 12-14 years living in a London suburb (Nelson *et al* 1993). A previous assessment of iron status among 234 Irish adolescents (age 14.5-18.4 years) taken 12 years ago found that 40% had low iron stores based on a SF $\leq$ 10μg/L (Armstrong 1989).

Iron is needed to cover basal losses in cells shed from the body, to replace that lost by menstruation and to provide the amounts required for growth, including pregnancy (Scientific Committee for Food 1993). Menstrual losses in teenage girls are about the same as in adult women (Hallberg and Rossander-Hulten 1991). In adolescent boys, haemoglobin concentration increases between 5-10g/L/year in response to sexual maturation that occurs at about the same time as the peak year of their growth spurt when the average weight gain is 10kg (Karlberg *et al* 1976). Given these high requirements for iron among young adolescents it is important that the bioavailable nutrient density for iron is high in their diets (Hallberg 1981*a*).

The dietary absorption of non-haem iron is very dependent on iron status and the balance between substances that enhance the absorption of non-haem iron (e.g. vitamin C, meat, fish) and those that inhibit it (e.g. phytate, calcium; Hallberg 1981b, Scientific Committee for Food 1993). This may explain the negative association of non-haem iron (sources include breads, cereals, fruits and vegetables) with iron tissue stores among 12-year-old girls. Those subjects in the highest quartile of iron status were found to report a higher consumption of meat, fish and poultry (table 5(a) and (b)). Haem iron in meat and meat products amounts to about 1-2mg/d in most EU countries with about 25% being absorbed almost independently of meal composition or iron status (the greater the body's need for iron, the higher the percentage of dietary iron absorbed; Rybo *et al* 1985; Hallberg L 1981*b*; Scientific Committee for Food 1993). It is previously reported that factors determining absorption may be more relevant to iron status than the absolute intake of iron (Passmore and Eastwood 1986). Diets with little red meat (<50g/d) or little fruit and vegetable accompanying meals, or having a high phytate content due to a high consumption of cereal fibre may have lower bioavailability (Hallberg and Rossander-Hulten 1991).

The folate status of these Dublin schoolchildren was found to be adequate with no prevalence of deficient folate stores in the one-year follow-up despite a reported low folate intake. The main contributing food group to folate status was foodstuffs fortified with folic acid: breakfast cereals and milk products. The introduction of folic acid fortification is reported to have significantly improved folate nutritional status and folic acid intake in a number of populations (Choumenkovitch *et al* 2001; McNulty *et al* 1996). Indeed, fortified breakfast cereals have been shown to contribute significantly to intakes of a variety of nutrients (Norris *et al* 1997; McNulty *et al* 1996). Folic acid fortification offers the most promising means of ensuring that the recommended levels are reached by the target population - that is, all women of child-bearing age-as the main dietary sources of folate are poorly consumed (e.g. dark green leafy vegetables) and have a poorer bioavailability (McNulty *et al* 1996; Cuskelly *et al* 1996). The proportion of subjects in the present study habitually consuming fortified breakfast cereals (56% (*n* 44) boys and 53% (*n* 55) girls) at age 12 years was lower than that reported among 16-17-year-old British adolescents (79% of boys and 63% of girls; Crawley 1993) and 12 and 15-year-old Northern Irish adolescents (94% of boys and 83% of girls; McNulty *et al* 1996).

Among girls, socio-economic advantages were found to consistently predict iron status. Numerous studies have demonstrated that the health of individuals from the lower end of the socio-economic scale is markedly worse than that of individuals from the upper end (Adamson *et al* 1992; Nelson *et al* 1993; Doyle *et al* 1994). A dietary intake of a wide variety of foods is preferred over nutrient supplementation as a method of obtaining adequate nutrient intake. However, the implications of continued deficiencies of these nutrients for immediate and future adult health include anaemia, impaired mental performance, decreased immunity, osteoporosis, increased risk of cancer and ischaemic heart disease (Olmedilla and Granado 2000). Supplementation seems a viable resource to safeguard longterm health given these diseases are more prevalent among socially disadvantaged individuals. Supplement use is more likely among higher socio-economic groups (Bristow *et al* 1997), that is, those who probably least require nutrient supplements as reported in this study. Approximately one in three young Dublin adolescents in the present study take a vitamin/mineral supplement but this was more likely to be reported among the higher social classes and, in 12-year-old children among those in the highest quartile of folate status. A US study of 423 adolescents reported that those who used supplements, even on an infrequent basis, consumed diets that are more nutrient-dense than those who did not use supplements (Stang *et al* 2000). Interestingly, the reported consumption of meat, fish and poultry was higher among those in the lowest quartile of tissue stores of folate. As discussed above these are important bioavailable sources of haem iron, particularly among those who have low tissue stores of iron. This could imply that any recommendation to improve iron status by increasing the consumption of meat, fish and poultry may decrease tissue stores of folate. However, the contribution of these foods to folate intake is likely to be very poor as they are not a major food source of folate and, especially after cooking and a recommendation to increase the consumption of foods fortified with folic acid will counteract any negative effect. Indeed, those in the lowest quartiles of folate status still retained adequate stores (> 100μg/L).

Current Irish recommendations include four or more portions of fruit and vegetables in the diet because they are a rich source of micronutrients such as folic acid (NAG 1995). The higher consumption of potato crisps, chocolate and non-chocolate confectionery reported among those with the lowest quartiles of tissue stores at age 12-years may have replaced more nutrient-dense foods in the diet. Although, snacks have been reported to contribute 26% iron and 33% of calcium to the dietary intake of adolescents living in Northern Ireland (Robson and Strain 1991). However, eating patterns established during adolescence shape diet later in life (Nicklas *et al* 1988). It is prudent, therefore, that the consumption of fruit and vegetables among young adolescents is encouraged as a healthy eating initiative. Major barriers to eating more fruits, vegetables and dairy products and eating fewer high fat products among adolescents include a lack of sense of urgency about personal health and taste preferences for other foods (Neumark-Sztainer *et al* 1999).

The concentration of circulating serum transferrin receptor has been suggested to provide an accurate and sensitive measure of iron depletion and of iron deficiency at the tissue level in those with depleted iron stores (Skikne *et al* 1990) independently of chronic disease status. However, little is known about serum transferrin receptor concentrations in children. In the present study there was no difference in serum transferrin receptor concentration between the quartiles of serum ferritin concentrations (data not shown). A high serum transferrin receptor concentration in 11- and 12-year-old healthy boys, compared to healthy adults, is reported to be a response to physiologically lower iron stores, rather than iron deficiency, highlighting the necessity of age-specific reference concentrations for serum transferrin receptor (Virtanen *et al* 1999).

The findings reported in this study suggest that reported low intakes of micronutrients are likely to occur as a result of under-reporting habitual intakes and were not concurrent with low tissue stores. Therefore the nutritional status of these children at a young adolescent age appears to be quite adequate, suggesting that either a physical or environmental occurrence at a later age predisposes the prevalence the low tissue stores reported elsewhere. The measurement of tissue stores of iron and folate are relatively simple and economic to assess (given the accessibility to automated equipment). It is proposed that in light of the scanty evidence upon which current reference nutrient intakes are based and the marked prevalence of under-reporting energy intake among schoolchildren that determination of tissue stores should be used to assess nutrient status. The advantages to this practice include the use of well-established biochemical cut-offs that define deficiency based on physical markers.

5. 5 References.

Adamson R, Rugg-Gunn A, Butler T, Appleton D, Hackett A (1992): Nutritional intake, height and weight of 11- and 12-year-old Northumbrian children in 1990 compared with information obtained in 1980. *British Journal of Nutrition.* **68,** 543-563

Allen J, Backstrom KR, Cooper JA, Cooper MC, Detwiler TC, Essex DW, Fritz RP, Means Jr RT, Meier PB, Pearlman SR, Roitman-Johson B, Seligman PA (1998): measurement of soluble transferrin receptor in serum of healthy adults. *Clinical Chemistry.* **44(1),** 35-39

Armstrong PL (1989): Iron deficiency in adolescents. *British Medical Journal.* **298,** 499

Bingham SA (1987): The dietary assessment of individuals; methods, accuracy, new techniques and recommendations. *Nutrition Abstracts and Reviews (Series A).* **57 (10),** 705-742

Bristow A, Qureshi S, Rona RJ, Chinn S (1997): The use of nutritional supplements by 4-12 year olds in England and Scotland. *European Journal of Clinical Nutrition.* **51,** 366-369

Carriquiry AL (1999): Assessing the prevalence of nutrient inadequacy. *Public Health Nutrition.* **2(1),** 23-33

Choumenkovitch SF, Jacques PF, Nadeau MR, Wilson PWF, Rosenberg IH, Selhub J (2001): Folic acid fortification increases red blood cell folate concentrations in the Framingham Study. *Journal of Nutrition.* **131,** 3277-3280

Crawley HF (1993): The role of breakfast cereals in the diets of 16-17 year old teenagers in Britain. *Journal of Human Nutrition and Dietetics.* **6,** 205-216

Cuskelly GJ, McNulty H, Scott JM (1996): Effect of increasing dietary folate on red cell folate: implications for the prevention of neural tube defects. *Lancet.* **347,** 657-659

Dallman PR (1977): New approaches to screening for iron deficiency. *The Journal of Paediatrics.* **90 (4),** 678-681

Department of Health (1991): *Dietary Reference Values for Food and Energy and for the United Kingdom.* Report on Health and Social Subjects. London: H. M. Stationary Office, **41**

Doyle W, Jenkins S, Crawford MA, Puvandendran K (1994): Nutritional status of schoolchildren in an inner city area. *Archives of Disease in Childhood.* **70,** 376-381

Dwyer J (1981): Nutritional requirements of adolescence. *Nutrition Reviews.* **39,** 56-72

Dwyer JT (1996): Adolescence. In: *Present Knowledge in Nutrition*, 7th edn, eds. EE Ziegler and LJ Filer Jr. Washington, DC: ILSI Press, pp 404-413

Emmons L, Hayes M (1973): Accuracy of 24hr recalls of young children. *Journal Of American Dietetic Association.* **62,** 409-415

Hallberg L (1981*a*): Bioavailable nutrient density: a new concept applied to the interpretation of food iron absorption data. *American Journal of Clinical Nutrition.* **34,** 2242-2247

Hallberg L (1981*b*): Bioavailability of dietary iron in man. *Annual reviews in Nutrition.* **1,** 123-147

Hallberg L, Rossander-Hulten L (1991): Iron requirements in menstruating women. *American Journal of Clinical Nutrition.* **54,** 1047-1058

Hurson M, Corish C (1997): Evaluation of lifestyle, food consumption and nutrient intake patterns among Irish teenagers. *Irish Journal of Medicine.* **166(4),** 225-230

Krishnaswamy K, Nair KM (2001): Importance of folate in human nutrition. *British Journal of Nutrition.* **85,** Suppl. 2, S115-S124

Karlberg P, Taranger J, Engstrom I, Lichtenstein H, Svennberg-Redegren I (1976): The somatic development of children in a Swedish urban community. A prospective longitudinal study. *Acta Peadiatric Scand.* Suppl 258

Livingstone MBE, Robson PJ (2000): Measurement of dietary intake in children. *Proceedings of the Nutrition Society.* **59,** 279-293

Lachance PA (1998): Overview of key nutrients: micronutrient aspects. *Nutrition Reviews.* **56,** S34-S39

McNulty H, Eaton-Evans J, Cran G, Woulahan G, Boreham C, Savage JM, Fletcher R, Strain JJ (1996): Nutrient intakes and impact of fortified breakfast cereals in schoolchildren. *Archives of Disease in Childhood.* **75,** 474-481

Miller JZ, Kimes T, Hui S, Andon MB, Johnston CC (1991): Nutrient intake variability in a pediatric population: implications for study design. *Journal of Nutrition.* **121,** 265-274

Molloy AM, Scott JM (1997): Microbiological assay for serum, plasma, and red cell folate using cyropreserved, microtitre plate method. *Methods in Enzymology.* **281,** 43-53

Nelson M (1996): Anaemia in adolescent girls: effect on cognitive function and activity. *Proceedings of the Nutrition Society.* **55,** 359-367

Nelson M, white J, Rhodes C (1993): Haemoglobin, ferritin, and iron intakes in British children aged 12-14 years: a preliminary investigation. *British Journal of Nutrition.* **70,** 147-155

Nelson M, Black AE, Morris JA, Cole TJ (1989): Between- and within-subject variation in nutrient intake from infancy to old age: estimating the number of days required to rank dietary intakes with desired precision. *American Journal of Clinical Nutrition.* **50,** 155-167

Neumark-Sztainer D, Story M, Perry C, Casey MA (1999): Factors influencing food choices of adolescents: findings from focus-group discussions with adolescents. *Journal of the American Dietetic Association.* **99,** 929-934, 937

Nicklas TA, Farris RP, Smoak CG, Frank GC, Srinivasan SR, Webber LS, Berenson GS (1988): Dietary factors relate to cardiovascular risk factors in early life: the Bogalusa Heart Study. *Arteriosclerosis.* **8,** 193-199

Norris J, Harnack L, Carmichael S, Pouane T, Wakimoto P, Block G (1997): US trends in nutrient intakes: the 1987 and 1992 national health interview surveys. *American Journal of Public Health.* **87,** 740-746

Nutrition Advisory Group (1995): *Recommendations for a Food and Nutrition Policy for Ireland. Government Publications*, Dublin.

Olmedilla B, Granado F (2000): Growth and micronutrient needs of adolescents. *European Journal of Clinical Nutrition.* **54,** Suppl 1, S11-S15

Passmore R, Eastwood MA, eds (1986): *Human Nutrition and Dietetics.* 8th edition. Churchill Livingstone: Hong Kong

Robson PJ, Strain JJ (1991): Snack energy and nutrient intakes of Northern Ireland adolescents. *Proceedings of the Nutrition Society.* **50(3),** 180A

Ryan YM, O'Donoghue M, Cantwell M, Johson H, Flynn MAT (1997a): Milk avoidance and dietary calcium intakes of Irish teenage girls. *Proceedings of Nutrition Society.* **56,** 50A

Ryan YM, Gibney MJ, Johnson H, Flynn MAT (1997b): Meat avoidance, weight perceptions and nutrient intakes of Irish teenage girls. *Proceedings of the Nutrition Society.* **56,** 49A

Rybo E, bengtsson C, Hallberg L (1985): The relative importance of various laboratory measurements in the diagnosis of iron deficiency. *Scandanavian Journal of Haemotology.* **Suppl 43,** 57-75

Sauberlich HE, Skala JH, Dowdy RP (174): *Laboratory Tests for the Assessment of Nutritional Status.* CRC Press: Cleveland, 49-60

Scientific Committee for Food, Commission of the European Communities (1993): Nutrient and energy intakes for the European Community, *Reports of the Scientific Committee for Food, 31st series.* Luxembourg: Office for Official Publications of the European Committees

Scott JM, Kirke PNGWD (1990): The role of nutrition in neural tube defects. *Annual Review of Nutrition.* **10,** 227-295

Skikne BS, Flowers CH, Cook JD (1990): Serum transferrin receptor: a quantitative measure of tissue iron deficiency. *Blood.* **75,** 1870-1876

Southon S, Bailey AL, Wright AJA, Belsten J, Finglas PM (1993): Micronutrient undernutrition in British schoolchildren. *Proceedings of the Nutrition Society.* **52,** 155-163

Stang J, Story MT, Harnack L, Neumark-Sztainer D (2000): Relationships between vitamin and mineral supplement use, dietary intake, and dietary adequacy among adolescents. *Journal of the American Dietetic Association.* **100,** 905-910

Torun B, Davies PSW, Livingstone MBE, Paolisso M, Sackett R, Spurr GB (1996): Energy requirements and dietary energy recommendations for children and adolescents 1 to 18 years old. *European Journal of Clinical Nutrition.* **50,** Suppl.1, S37-S81

van de Vijver LPL, Kardinaal AFM, Charzewska J, Rotily M, Charles P, Maggiolini M, Ando S, Vaananen K, Wajszczyk B, Heikkinen J, deloraine A, Schaafsma G (1999): Calcium intake is weakly but consistently negatively associated with iron status in girls and women in six European countries. *Journal of Nutrition.* **129,** 963-968

Virtanen MA, Vinikka LU, Virtanen MKG, Svahn JCE, Antilla RM, Krusius T, Cook JD, Axelsson IEM, Raiha NCR, Siimes MA (1999): Higher concentrations of serum transferrin receptor in children than in adults. *American Journal of Clinical Nutrition.* **69,** 256-260

Wald NJ, Watt HC, Law MR, Weir DG, McPartlin J, Scott JM (1998): Homocysteine and ischaemic heart disease. *Archives of Internal Medicine.* **158,** 862-867

WHO (1996): *Preparation and Use of Food-based Dietary Guidelines,* NUT/96.6. Geneva: WHO

Chapter 6

Diet and dental health of young Dublin adolescent schoolchildren.

6.1 Introduction.

Dental caries is one of the most widespread oral diseases (WHO 1998). Its causation has been associated with fermentable carbohydrates, particularly sugar but also finely ground and heat-treated starch or cooked starchy foods, since the beginning of scientific approaches to dental problems (WHO 1998; van der Hoevan and van der Palenstein Helderman 1998). However, there is a general agreement that a marked reduction in caries prevalence has occurred among children in most industrialised countries (Petersson and Bratthall 1996). Available data clearly indicate that the decision taken in 1960 to fluoridate the national water supplies, as well as the widespread and increasing use of fluoride containing toothpastes, have played a major role in the decline of dental caries, from a mean decayed, missing and filled tooth (DMFT) score of 5.2 in 1961-1963 to 2.2 in 1984 observed among 12-year-old Irish children (O'Mullane and Whelton 1994).

The lack of change in sugar disappearance figures for Ireland over the last 30 years do not tally with the observed decline in dental caries (O'Mullane and Whelton 1994). Similarly, in Sweden, Norway and New Zealand, sugar consumption between 1982 and 1985 increased, but nevertheless, regular epidemiological monitoring of caries data showed that the caries prevalence in children continued to decrease (WHO 1998), suggesting that the amount of sugar eaten has no influence. The frequency of ingestion and duration in the mouth of dietary sugars are important aspects of caries as indicated by the Stephan curve that shows the pH response in plaque to sugars plotted against time (Arens 1998; Kashet *et al* 1996). However, there is no completely efficient 'self-cleansing' mechanism in the mouth for the sites at risk. The best measure to prevent dental caries is the regular removal of dental plaque with a toothbrush and the use of fluoride toothpaste twice a day (WHO 1998). It helps to remove food debris and to minimise dental plaque, inhibits the metabolism of sugars to acids by acidogenic bacteria, while fluoride promotes the remineralisation of teeth. Therefore, while dietary sugars are a determinant in the development of caries, they are not the most important factor in the aetiology of the disease (WHO 1998).

Inequalities between socio-economic status and prevalence of dental caries have been reported among schoolchildren. In England, for both 12- and 15-year-olds there was an independent association between social class and the number of DMFT (O'Brien 1994). The levels of dental caries experience and untreated caries among adolescents in Northern Ireland have also been related to socio-economic variables (Kinirons and Stewart 1998), where those from less advantaged backgrounds have the highest prevalence of dental caries.

There are foods that have anti-cariogenic properties, protecting the teeth from decay. Milk and cheese contain calcium, phosphate and casein, all of which are anti-cariogenic. Additionally, cheese is a strong gustatory stimulant to salivary flow that helps to neutralise dental plaque acids, thus preventing dental caries development (Moynihan 2000).

The purpose of the present study was to examine the significance of socio-economic class, dental hygiene practice and diet on the prevalence of dental caries among young Dublin schoolchildren.

6.2 Subjects and Methods.

6.2.1 Subjects.

Subjects were recruited for this study through Dublin city primary schools as described in chapters 2.1 and 2.2. A random sample of 30% of the children recruited (*n* 130, 58 boys, 72 girls, mean age 11 years), controlled equally for sex and schooltype attended had their teeth examined by a qualified dentist and completed two food diaries on two separate occasions.

6.2.2 Socio-economic class.

Social background was classified according to the highest classed earner within a household as described in chapter 4.2.2. For the purpose of meaningful statistical analysis O'Hare's socio-economic classes one and two and three to six were combined to form a professional and non-professional class, respectively.

6.2.3 Dental hygiene practices.

Dental hygiene practices were reported by questionnaire as described in chapter 2.4. Pocket-money was reported in terms of the amount, frequency of receiving and spending in an interview assisted questionnaire described in chapter and sub-sections 2.5.

6.2.4 Dental examination.

Dental examination for the number of decayed, missing and filled teeth (DMFT) was completed at each school using WHO criteria by a trained dentist from the Dublin Dental Hospital. The dentist used the same subject identification numbers, allocated to each individual for the present study, and this allowed dental and nutritional data to be merged for statistical analysis. Dental caries was identified as a score of DMFT greater than zero.

6.2.5 Dietary intake.

Dietary intake was recorded in two-day food diaries on two occasions separated by three weeks as described in chapter and sub-sections 2.8.

Frequency of food consumption per day was defined as the number of eating occasions at which the food was consumed divided by the number of days recorded. Specific foods known to be a source of fermentable carbohydrate were grouped: unsweetened/pure fruit juice; sweet fruit juice and cordials/squash; plain, fancy biscuits, cakes and pastries; chocolate confectionery; non-chocolate confectionery; soft/fizzy drinks; table sugar, preserves and syrups; and potato and savoury (highly processed starch only) snack products (e.g. crisps, potato and corn snacks, etc.). Milk (full, low fat and skimmed) and cheese were considered as anti-cariogenic foods. For stepwise logistic regression these variables were further combined to form five groups representing the amount and the frequency of: 1) chocolate confectionery, 2) non-chocolate confectionery, sugar, preserves and syrups, 3) fizzy drinks, sweetened fruit juices and pure fruit juices, 4) potato and corn snacks, and 5) milk and cheese.

6.2.6 Data management and statistical analysis.

All data was coded for entry into the Statistical Package for Social Sciences (SPSS) version 10.0 for Windows. Nutritional data from WISP was merged with questionnaire and dental data in SPSS for statistical analysis. "Don't know" and "none of the above" answers were omitted from analysis. Variables were analysed in terms of those who had caries compared to those who were caries free, those from professional SEC compared to those who were from non-professional, using χ^2 test, Mann-Whitney U and independent t-test, as appropriate. Spearman's correlation assessed association between bivariate variables and multiple regression analysis assessed predictors of dental caries. A significant difference was indicated by a p-value ≤ 0.05.

6.3 Results.

Approximately thirty-four percent (*n* 44, 20 boys, 24 girls, mean age 10.8 years) of the subjects had dental caries with a mean (SD) DMFT score of 1.95 (1.72). Unsurprisingly, these children with caries were more likely than subjects without caries to report toothache (82% (*n* 32) *vs*. 48% (*n* 38), $p \leq 0.001$), tooth fillings (74% (*n* 32) *vs*. 38% (*n* 32), $p \leq 0.001$), tooth abscesses (21% (*n* 9) *vs*. 6% (*n* 5), $p < 0.05$) and tooth extractions (23% (*n* 10) *vs*. 8% (*n* 7), $p < 0.05$).

The cohort examined by the dentist was representative of both schooltypes but this was not reflected in the numbers representing categories of SEC with 58% (*n* 75), 19% (*n* 25), and 21% (*n* 27) classified respectively as SEC one, two and three (O'Hare 1982); 2% (*n* 3) were unclassified. Therefore, the SEC groups were combined as described above to 58% (*n* 75) professional SEC and 40% (*n* 52) non-professional SEC.

A comparison of demographics and dental hygiene practices between the subjects with and without caries is shown in table 1. As SEC was associated with dental caries experience a comparison of dental hygiene practices and experiences according to SEC was performed. This found that professional groups reported visiting the dentist more often than non-professional groups (90% (*n* 62) *vs*. 59% (*n* 24), $p \leq 0.001$). In tandem with the higher caries experience among the non-professional group, compared to the professional group, the former were also more likely to report tooth extraction (26% (*n* 13) *vs*. 5% (*n* 4), $p \leq 0.05$), tooth abscesses (23% (*n* 11) *vs*. 4% (*n* 3), $p \leq 0.05$), and toothache (73% (*n* 35) *vs*. 52% (*n* 35), $p \leq 0.05$).

The mean ratio of energy intake to estimated basal metabolic rate (EI:BMR_{est}) was 1.45 among boys and 1.52 among girls indicating that reported dietary intakes among the sexes are representative of habitual intakes (Torun *et al* 1996). As we have previously reported that children seem to purposefully under-report snack foods (chapter 4.4), a comparison of DMFT between subjects identified as under-reporters (35%, *n* 46) and adequate reporters (59%, *n* 76) found that caries experience is comparable. The mean daily intake and frequency of consumption of cariogenic and anti-cariogenic foods is shown in table 2 according to caries experience and in table 3 according to SEC. In addition, subjects with caries were found to report fewer meals per day compared to subjects with no caries (2.4 (0.6) *vs.* 2.6 (0.6), respectively, $p \leq 0.05$). The non-professional SEC group were also found to report fewer meals per day compared to the professional group (2.3 (0.5) *vs.* 2.7 (0.6), respectively, $p \leq 0.05$).

Rank correlations of DMFT with SEC and dietary factors (listed in tables 2 and 3) found relatively weak associations (in decreasing order) for: SEC ranked from highest to lowest class (r 0.279, $P \leq 0.05$), number of meals per day (r -0.266 $P \leq 0.05$), frequency of taking sweetened fruit juice/squash (r -0.252, $P \leq 0.05$), dental visits ranked from frequent to infrequent (r 0.251, $P \leq 0.05$) and amount of chocolate eaten per day (r 0.213, $P \leq 0.05$). When under-reporters were excluded fewer correlations to DMFT were found and these included: SEC (r 0.267, $P \leq 0.05$), the frequency of taking sweetened fruit juice/squash (r -0.273) and the number of meals per day (r -0.238, $P \leq 0.05$).

Correlations of reported demographic, dental hygiene practice and the cariogenic and anti-cariogenic foods with DMFT scores according to SEC found no associations among the professional group. However, among the non-professional group positive associations between DMFT and chocolate confectionery (r 0.391, $P \leq 0.05$) and the frequency of eating chocolate confectionery (r 0.330, $P \leq 0.05$) while a negative association was found between DMFT and the number of meals per day (r -0.390, $P \leq 0.05$).

Predictors of dental caries were identified by multiple logistic regression. The independent variables included the categorical variables: sex, frequency of dental visits, social class, and toothbrushing frequency, and the quantitative variables: age, number of snacks and meals per day, and the amount and frequency of dietary variables combined as described in chapter 6.2.5. The only independent variable left in the model explaining 67% of the variance in caries experience was SEC (Odds ratio 0.296, CI: 0.094-0.935, $P \leq 0.05$) suggesting that toothbrushing frequency and dietary factors had no impact on dental caries compared to SEC.

Ninety-five percent (*n* 120) of subjects advocated that sugar eaten several times during the day causes bad teeth, 51% (*n* 65) advocated that sugar will provide instant energy for sport, and 49% (*n* 62) advocated that sugar will "make you fat", comparable for SEC and caries groupings. In reply to "how much toothpaste should be placed on toothbrushes" 75% (*n* 64) subjects with no caries compared to 50% (*n* 22) of subjects with caries knew that the correct answer was the "size of a pea" ($p < 0.05$); the remaining 50% (*n* 22) of subjects with caries chose "cover the whole brush".

The non-professional group were more likely to receive pocket-money than the professional group (90% (*n* 37) *vs.* 75% (*n* 53), respectively, $p = 0.051$). Sixty-two percent (*n* 80) of subjects report that they receive pocket money once a week or more often, comparable between the SEC. Fifty percent (*n* 20) of the non-professional group report receiving greater than £3 compared to 29% (*n* 16) of the professional group ($p = 0.054$). The non-professional SEC, compared to the professional SEC, was more likely to report spending their pocket-money on fruit and fruit juices (43% (*n* 19) *vs.* 10% (*n* 7), respectively, $p \leq 0.001$), fizzy drinks (66% (*n* 29) *vs.* 31% (*n* 23), respectively, $p \leq 0.001$), take-aways (39% (*n* 17) *vs.* 8% (*n* 6), respectively, $p \leq 0.001$), ice-pops (46% (*n* 20) *vs.* 26% (*n* 19), respectively, $p \leq 0.05$) and crisps (50% (*n* 20) *vs.* 22% (*n* 16), respectively, $p \leq 0.05$).

Table 1: The proportion, % (*n*), of young Dublin adolescent schoolchildren (*n* 130, mean age 11 years) with dental caries (*n* 44) and caries free (*n* 86) according to reported demographics and dental hygiene practices.

Reported demographics and dental hygiene practices	Dental caries present (*n* 44) % (*n*)	Dental caries free (*n* 86) % (*n*)
Gender		
Male	46 (20)	44 (38)
Female	55 (24)	56 (48)
Socio-economic class		
Professional	42 (18)	68 (57)*
Non-professional	58 (25)	32 (27)*
Schooltype		
Fee-paying	41 (18)	58 (50)
Non-fee-paying	59 (26)	42 (36)
Reported toothbrushing habits		
More than twice per day	79 (34)	73 (62)
Less than twice per day	21 (9)	27 (23)
Frequency of dental examinations		
Every two years or more	63 (24)	85 (64)*
Less than every two years	34 (14)	15 (11)*
Reported eating occasions	Mean (SD)	Mean (SD)
Total number per day	4.8 (0.9)	5.1 (1.2)
Meals per day	2.4 (0.6)	2.6 (0.6)*
Snacks per day	2.4 (1.0)	2.4 (1.1)

*Significantly different from subjects with dental caries, $p \leq 0.05$

Table 2: The mean daily intake (g/d) and the frequency of consumption (eating occasions per day) of cariogenic and anti-cariogenic food factors according to caries experience among young Dublin adolescent schoolchildren (*n* 130, mean age 11 years)

Food factors	Caries present (n 44)		Caries free (n 86)	
	Mean	SD	Mean	SD
Energy (MJ/d)	8.2	2.0	7.9	1.9
Sugar (g/d)	118.6	41.0	111.7	37.0
% sugar	22.5	4.0	22.3	5.4
Amount (g/d)				
Potato and savoury snacks	23.7	17.7	22.8	13.1
Chocolate confectionery	38.8	23.9	29.4*	21.5
Non-chocolate confectionery	19.5	16.8	16.7	16.3
Sugar, preserves and syrups	10.9	8.8	8.3	7.9
Unsweetened fruit juice	139.1	73.0	174.2	133.3
Sweetened fruit juice/squash	132.0	112.9	183.1	138.6
Fizzy drinks	290.2	277.0	199.9	146.8
Cakes, pastries and biscuits	38.3	29.6	35.3	27.1
Milk (all types)	228.4	139.0	266.9	204.4
Cheese	18.4	12.4	21.5	13.6
Frequency (eating occasions/day)				
Potato and savoury snacks	0.9	0.5	0.9	0.5
Chocolate confectionery	1.0	0.5	1.0	0.6
Non-chocolate confectionery	0.7	0.4	0.8	0.5
Sugar, preserves and syrups	1.0	0.6	0.9	0.6
Unsweetened fruit juice	0.6	0.3	0.8	0.6
Sweetened fruit juice/squash	0.6	0.5	0.8*	0.5
Fizzy drinks	0.9	1.0	0.7	0.6
Cakes, pastries and biscuits	0.8	0.5	1.0	0.7
Milk (all types)	1.4	0.6	1.4	0.7
Cheese	0.6	0.4	0.5	0.3

*Significantly different from group with caries, $p \leq 0.05$

Table 3: The mean daily intake (g/d) and the frequency of consumption (eating occasions per day) of cariogenic and anti-cariogenic food factors according to socio-economic grouping among young Dublin adolescent schoolchildren (*n* 130, mean age 11 years)

Food factors	Professional SEC (n 75) Mean	SD	Non-professional SEC (n 52) Mean	SD
Energy (MJ/d)	7.9	1.7	8.1	2.1
Sugar (g/d)	112.3	36.5	115.2	39.7
% sugar	22.4	5.0	22.2	5.0
Total number of eating occasions/d	5.1	1.2	4.8	1.0
Amount (g/d)				
Potato and savoury snacks	18.9	11.5	27.4*	14.1
Chocolate confectionery	28.4	20.6	37.2*	23.5
Non-ehocolate confectionery	16.7	16.8	18.4	15.0
Sugar, preserves and syrups	8.6	7.6	9.7	9.1
Unsweetened fruit juice	165.9	126.5	153.0	98.4
Sweetened fruit juice/squash	179.1	132.9	137.9	127.4
Fizzy drinks	171.9	123.0	293.3**	202.0
Cakes, pastries and biscuits	37.4	29.7	36.1	25.4
Milk (all types)	244.9	164.7	271.2	209.6
Cheese	21.8	14.0	18.3	11.8
Frequency (eating occasions/day)				
Potato and savoury snacks	0.8	0.5	0.9	0.5
Chocolate confeetionery	1.0	0.6	0.9	0.4
Non-chocolate confectionery	0.7	0.5	0.7	0.4
Sugar, preserves and syrups	0.8	0.6	1.0	0.6
Unsweetened fruit juice	0.8	0.6	0.7	0.4
Sweetened fruit juice/squash	0.8	0.5	0.7	0.5
Fizzy drinks	0.5	0.4	1.1*	0.9
Cakes, pastries and biscuits	1.1	0.7	0.8*	0.4
Milk (all types)	1.3	0.6	1.5	0.7
Cheese	0.6	0.3	0.5	0.4

*Significantly different from professional SEC group, $p \leq 0.05$
** Significantly different from professional SEC group, $p \leq 0.001$

6.4 Discussion.

One-third of Dublin adolescent schoolchildren were found to have dental caries at the age of 11 years. This represents a further decline in the prevalence of dental caries among Irish children (O'Mullane and Whelton 1994). Socio-economic class, rather than the amount or frequency of fermentable carbohydrates or toothbrushing had the strongest association with dental caries (table 1).

In 1984, the mean DMFT of 128 12-year-old children residing in the Eastern Health Board was 2.2 teeth. The mean DMFT of 1.95 teeth, reported among the 130 11-year-old children in this study, represents a decline of 11% in caries in the Dublin area over the last 15 years, or of 63% (from 5.2 teeth) since public water supplies were fluoridated in 1961 (O'Mullane and Whelton 1984). During the past few decades, caries incidence has been in constant decline (Harel-Raviv *et al* 1996) and has been attributed to the introduction of fluoride as an anticariogenic agent in the food chain, the increasing use of fluoride in toothpaste and food, and the use of sugar alcohols (including xylitol that may even have anticariogenic properties) such as dietary sweeteners during manufacturing (Harel-Raviv *et al* 1996; Petersson and Bratthall 1996; Navia 1994).

The trend of decreasing caries has not been matched by diminishing sugar consumption (Honkala and Tala 1987). Children with and without caries consumed equivalent amounts of total sugar both in terms of absolute amount and the sugar contribution to energy in the present study. Within a community poor correlations between total sugar intake and caries prevalence are now frequently reported (Harel-Raviv *et al* 1996). In fact, the relationship between sugar and caries frequency is ambiguous due to diverging results from different studies (Harel-Raviv *et al* 1996).

Sugar has been shown to be strongly promotive of caries and, in particular, between-meal snacks received attention because the frequency of sugar intake was found to be important (Holt 1991; Ainamo 1980). But recently, the consumption of sugar does not seem to be as strong a factor for the occurrence of caries as it used to be (Harel-Raviv *et al* 1996). Lachapelle *et al* evaluated the association between dietary patterns and dental caries among 11-year-old children and found no association between frequency of consumption of sugary foods and caries increments. Also, children with the highest dental caries increment were not necessarily the ones consuming sugary foods more frequently (Lachapelle *et al* 1990). Dental caries has declined or is comparable in populations of high sugar consumption compared to controls (McMahon *et al* 1993; Larsson *et al* 1992; Rugarbaum *et al* 1990).

It has been concluded that, without doubt, sugar has a role in caries development but the degree of incrimination of sugar is grossly exaggerated (Cleaton Jones and Walker 1989). Such are these findings in epidemiological studies during the 1990s that the WHO recently advocated that dental health problems do not require any dietary recommendations in addition to, or other than, those required for maintenance of general health (WHO 1998).

Omissions are a recognised problem in correctly assessing snacks, or foods with an unhealthy image, and it has also been reported that frequency of consumption of foods tends to be underestimated in questionnaires by those who are frequent consumers (Persson and Carlgren 1984). In chapter 4, it was reported that specific foods, including cakes and pastries, sugars, preserves and syrups, and chocolate confectionery, were consumed in significantly lower amounts by under-reporters of dietary intake. This was in spite of energy intake being significantly lower which would usually imply that overall food intake should be lower. Therefore, underreporting habitual intake could reasonably be expected to produce biased results when assessing the influence of these "snack" foods on dental caries. Nonetheless, excluding under-reporters from analysis of caries experience found even fewer associations between dietary factors whereas SEC consistently had an influence on caries prevalence.

Children who come from homes where income is low are likely to have more caries and more untreated caries (or fewer dental visits) than children from higher income households (Arens 1999; Kinirons and Stewart 1998; Vagras *et al* 1998). Although, both SEC reported comparable toothbrushing frequency in this study, it has been reported that belonging to a high social class can be associated with cleaning teeth more effectively and frequently and with the use of more oral hygiene aids than those of lower social class (Todd and Lader 1991). Factors other than dental hygiene and consumption of fermentable carbohydrates may explain the SEC differentiation that are currently being evaluated. For example, a recent study has associated maternal smoking with dental caries among toddlers regardless of SEC. Nonetheless, smoking was found to be more common among less advantaged SEC (Williams *et al* 2000).

Cross-sectional studies, in which diet and dental caries levels at one point in time are measured and compared, should be interpreted with caution. Dental caries develops over time and therefore current diet may not be responsible for the levels of caries - it may be the level of intake and frequency of sugars many years earlier that are responsible for current disease (Navia 1994). Twice as many children of non-professional, compared to professional SEC, reported buying fizzy drinks with their pocket money and indeed, were found to drink these more frequently and in larger quantities. Although not found in this study, reported consumption of sugared and carbonated drinks has been associated with higher levels of dental caries among 6,014 14-year-old English adolescents (Jones *et al* 1999). Intake of acidic foods and drinks contributes to dental erosion (loss of tooth tissue), which is distinctive from caries in that there is no known bacterial involvement. Whereas dental caries seems to be on the decline, tooth erosion is reported to be increasing in prevalence among British children and is associated with an increased consumption of acidic drinks (O'Brien 1994). Therefore, although not predictive of dental caries, it is likely that the more frequent and higher consumption of fizzy drinks puts non-professional children in the current study at high risk of having or developing dental erosion.

Children from non-professional SEC represent a nutritionally vulnerable group and dental caries is just one in the list of chronic diseases they are consequently at risk of. Prevention of dental caries, however, may offer short-term motivation to choose non-sugary foods in line with the guidelines for a healthy balanced diet (NAG 1995). In addition, public health initiatives may target lower socio-economic groups where the pattern of fizzy drink consumption represents high risk of dental erosion.

6.5 References.

Ainamo J (1980): Relative roles of toothbrushing, sucrose consumption and fluorides in the maintenance of oral health in children. *International Dental Journal.* **30,** 54-66

Arens U (1998): *Oral health Diet and Other Factors.* Arens U, ed. Amsterdam, Elsevier

Arens U (1999): *Oral Health, Diet and Other Factors.* Amsterdam: The Report of the British Nutrition Foundations Task Force

Cleaton Jones PE, Walker A (1989): Sugar intake and dental caries: where do we stand? *Journal of Dentistry in Childhood.* **56,** 30-35

Crawley H (1988): Food portion sizes. *Ministry of Agriculture, Fisheries and Food.* HMSO

Harel-Raviv M, Laskaris M, Sam Chu K (1996): Dental caries and sugar consumption in the 21st century. *American Journal of Dentistry.* **9,** 184-190

Holt RD (1991): Foods and drinks at 4 daily time intervals in a group of young children. *British Dental Journal.* **170,** 137-143

Honkala E, Tala H (1987): Total sugar consumption and dental caries in Europe. An overview. *International Dental Journal.* **37,** 185-191

Jones C, Woods K, Whittle G, Worthington H, Taylor G (1999): Sugar, drinks, deprovation and dental caries in 14-year-old children in the north west of England in 1995. *Community Dental Health.* **16,** 68-71

Kashet S, Zhang J, van Houte J (1996): Accumulation of fermentable sugars and metabolic acids in food particles that become entrapped on the dentition. *Journal of Dental Research.* **75(11),** 1885-1891

Kinirons MJ, Stewart C (1998): Factors affecting levels of untreated caries in a sample of 14 – 15-year-old adolescents in Northern Ireland. *Community Dentistry and Oral Epidemiology.* **26,** 7-11

Lachapelle D, Couture C, Brodeur JM, Sevigny J (1990): The effects of nutritional quality and frequency of consumption of sugary foods on dental caries increment. *Canadian Journal of Public Health.* **81,** 370-375

Larsson B, Johansson J, Ericson R (1992): Prevalence of caries in adolescents in relation to diet. *Community Dentistry and Oral Epidemiology.* **20,** 133-137

McMahon J, Parnell WR, Spears GFS (1993): Diet and dental caries in preschool children. *European Journal of Clinical Nutrition.* **47,** 794-802

Moynihan PJ (2000): Foods and factors that protect against dental caries. *British Nutrition Foundation.* **25,** 281-286

Navia JM (1994): Carbohydrates and dental health. *American Journal of Clinical Nutrition.* **59,** 719S-727S

Nutrition Advisory Group (1995): *Recommendations for a Food and Nutrition Policy for Ireland. Government Publications,* Dublin.

O'Brien M (1994): *Children's dental health in the United Kingdom 1993.* London, HMSO

O'Mullane D, Whelton H (1994): Caries prevalence in the Republic of Ireland. *International Dental Journal.* **44,** 387-391

Persson LA, Carlgren G (1984): Measuring children's diet: evaluation of dietary assessment techniques in infancy and childhood. *International Journal of Epidemiology.* **13,** 506-517

Petersson HG, Bratthall D (1996): The caries decline: a review of the reviews. *European Journal of Oral Sciences.* **104,** 436-443

Rugarbaum P, Frencken JE, Anuli JAD et al (1990): Caries experience amongst 12 and 15-year-old Tanzania children residing on a sugar estate. *Community Dental Health.* **7,** 53-58

Todd JE, Lader D (1991): *Adult Dental Health 1988 United Kingdom.* London: HM Stationary Office

Torun B, Davies PSW, Livingstone MBE, Paolisso M, Sackett R, Spurr GB (1996): Energy requirements and dietary energy recommendations for children and adolescents 1 to 18 years old. *European Journal of Clinical Nutrition.* **50,** Suppl.1, S37-S81

Vagras CM, Crall JJ, Schneider DA (1998): Sociodemographic distribution of peadiatric dental caries: NHANES III, 1988-1994. *Journal of the American Dental Association.* **129,** 1229-1238

van der Hoeven JS, van der Palenstein Helderman WH (1998): Microbial specificity and dental caries. In: Guggenheim B, Shapiro, eds. *Oral Biology at the Turn of the Century.* Basel: Karger, 43-55

Williams SA, Kwan SYL, Parsons S (2000): Parental smoking practices and caries experience in pre-school children. *Caries Research.* **34,** 117-122

World Health Organisation (1998): *Report on carbohydrates and human disease.* WHO/FAO, Paper no. 66: www.fao.org/es/esn/carboweb/carbo.htm

Chapter 7

Public health implications.

7.1 Main findings.

The prevalence of fear of fatness, a specific desire to be thinner, was reported among one in four of a representative group of Irish schoolchildren. It was particularly pervasive among girls (in the total group), and overweight girls. These young girls manifested their concerns by dieting to lose perceived or actual excess weight. Obesity has increased 5-fold and 2.5-fold over a ten year period among boys and girls respectively, in Ireland. However, the measurement of a secular trend over the year of the study was difficult to establish because of a lack of a standard assessment of weight status among Irish children.

Both fear of fatness and being overweight biased the reporting of energy intake both at baseline and at follow up. Nonetheless, energy intake was estimated to meet requirements for age- and sex- specific energy expenditure when it was based on reported physical activity levels. The reported intake of iron and folate, however, fell well short of estimated average requirements among a high proportion of children but these did not tally with estimates of actual tissue stores taken from blood samples. Deficiency of iron stores was found at baseline (7% boys and 8% girls) and follow up (3% of boys and 15% of girls). Social disadvantage emerged as a more important predictor than dietary factors of low iron stores among girls and of dental caries among the group.

7.2 Public health implications.

Young adolescents are physically and mentally developing and, subsequently have different nutrient requirements and cognitive abilities that affect the assessment of habitual diet (Livingstone and Robson 2000). This study adapted the traditional method of the food diary, used among adults, to report nutrient intakes and dietary patterns among young Irish adolescents. To support this method independent validation, including the measurement of age-specific EI:BMR and tissue stores of iron and folate, was used. In so doing, this study is the first in Ireland to validate energy intake among young adolescents and to measure actual tissue stores of iron and folate and to use these measurements as a ranking system related to reported food intakes and patterns.

Young adolescents who under-reported energy intake did not misrepresent their food intake in general, but rather seemed to target particular foods (for example, white bread, dairy products, biscuits, crisps, and confectionery; section 4.3, Table 5) that are associated with adult weight-loss regimes. This suggests that weight–conscious adolescents are, in fact, following a specified diet that avoids high calorie and/or high fat foods at a time when energy needs are high to meet the demands of growth. Although some of these foods fall in line with healthy eating guidelines, others do not as they represent a rich source of nutrients, particularly protein, iron and folate.

Girls, of any weight status, were more personally concerned about slimming, than boys. It has been suggested that this difference between the sexes is associated with societal influences which suggest that it is acceptable for men to be overweight but not for women (Rosen and Gross 1987). The high prevalence of fear of fatness among young adolescent girls, in the current study, suggests that body image concerns start at a younger preadolescent age, and increase to the rate of 59% (of 420 subjects) reported among 15-year-old Irish girls (Ryan *et al* 1998). Therefore, it can be reasonably assumed that the young girls in the current study are in a weight-loss trend that begins during childhood and increases in prevalence among teenage girls and into young adulthood.

Socio-economic disadvantage was a common thread that predicted nutritional vulnerability among young adolescents in terms of current health, whereas obesity, a long-term health concern, transcended socio-economic backgrounds. The prevalence of overweight has increased dramatically among young Irish adolescents over the last ten years and this trend was apparent even in this one-year follow up. There are serious health consequences accompanying the rising prevalence of childhood obesity, most notably an increasing trend of paediatric cases of type 2 diabetes (Rocchini 2002). Belonging to a lower income group was predictive of having low iron stores and more dental caries. Also, these young adolescents reported a higher consumption of acidic drinks that is associated with a risk of having dental erosion (O'Brien 1994). In particular, the existence of low iron stores, known to be associated with less than optimal behavior and poorer performance in intelligence tests (Pollitt 1990), among apparently healthy adolescents, is a serious public health concern.

Food-based dietary guidelines are proposed as a publicly acceptable means of translating nutrient targets, derived from analysis of the relationship between nutrient intake and disease prevalence, to the general population (Sandstrom 2001). This requires an understanding of the relation between foods, food patterns and nutrient intakes in the target population (Sandstrom 2001), which proved difficult to reach in the present study given the prevalence of energy under-reporting. Furthermore, the current recommendations for energy intake among Irish adolescents (FSAI 1999) did not accurately reflect actual body weights or estimated physical activity levels in Ireland and need to be revised before food-based dietary guidelines could be developed.

The measurement of tissue stores, in the current study, allowed an impression of long-term nutrient intake that suggested that the majority (the exception is discussed above) of young Irish adolescents meet recommended iron and folate intakes. This was in contrast to the short-term impression given by reported intakes. The day-to-day variability known to exist in the adolescent diet implies that a survey period of a duration significantly longer than that used in the present study or than that recommended for adult studies would be needed to translate nutrient intakes into food-based dietary guidelines (Lambe and Kearney 1999).

7.3 Conclusions

Given the increase in childhood obesity over the last ten years, it can be reasonably expected that a concurrent increase of adverse health conditions, which accompanying the condition of obesity, will occur. Furthermore, the current practice of adolescent dieting will likely only serve to enhance young adult obesity trends by the phenomenon of yo-yo dieting or weight cycling (Mellin *et al* 1992). The development of health promotion initiatives, such as healthy eating and active living that prevent overweight among adolescents without exacerbating the fear of fatness is urgently needed - particularly among older girls and overweight children.

"The excesses of our youth are cheques written against our age and they are payable with interest thirty years later"

- Monty Python

7.4 References.

Collins (1991): Body figure perceptions and preferences among preadolescent children. *Int J Eat Dis.* **10(2)**, 199-208.

Food Safety Authority of Ireland (1999): Children's energy and protein requirements. *Recommended Dietary Allowances for Ireland.* Dublin: Food Safety Authority of Ireland, 13-14; 16-17

Lambe J, Kearney J (1999): The influence of survey duration on estimates of food intakes – relevance for food-based dietary guidelines. *British Journal of Nutrition.* **81,** S139-142

Livingstone MBE, Robson PJ (2000): Measurement of dietary intake in children. *Proceedings of the Nutrition Society.* **59**, 279-293

Maffeis C, Grezzani A, Pietrobelli A, Provera S, Tato L (2001): Does waist circumference predict fat gain in children? *International Journal of Obesity.* **25**, 978-983

O'Brien M (1994): *Children's dental health in the United Kingdom 1993.* London, HMSO

Pollitt E (1990): *Malnutrition in the classroom.* Paris: UNESCO

Rocchini AP. (2002): Childhood obesity and a diabetes epidemic. *New England Journal of Medicine.* **346**: 854-55

Rosen JC, Gross J (1987): Prevalence of weight reducing and weight gaining in adolescent girls and boys. *Health Psychology.* **6(2),** 131-147

Ryan YM, Gibney MJ, Flynn MAT (1998): The pursuit of thinness: a study of Dublin schoolgirls aged 15y. *International Journal of Obesity.* **22**, 485-487

Sandstrom B (2001): A framework for food-based dietary guidelines in the European Union. *Public Health Nutrition.* **4(2A),** 293-305

Appendix A.1

Initial letter inviting schools to participate in study.

THE EATING HABITS OF IRISH GIRLS AND BOYS.

A study being carried out jointly by the Department of Biological Sciences, Kevin St., College of Technology and Trinity Centre for Health Sciences, St. James's Hospital.

Date: 15 June 1998.

Dear Principal

The quality of the dietary intake of Irish teenagers requires special attention. This is an age group that is particularly prone to nutritional deficiency due to rapid growth spurts. Research has shown that children can lack iron and other vitamins during this time. An inadequate dietary intake due to a fear of fatness has been found in Irish teenage girls. This also needs to be examined in boys and in younger adolescents to determine which age groups are most vulnerable. The prevalence of obesity has increased in all Western societies. Data from the U.S. shows that both children and adolescents are affected. We want to find out how these problems might affect Irish children.

During the school year 1998-1999 we intend to study the nutritional adequacy, body image concerns and slimming practices of 5^{th} and 6^{th} class primary schoolchildren from inner city Dublin schools of different socio-economic backgrounds. This will involve the children filling out a 20-minute questionnaire that tackles these issues. A random sample of children will then be asked to participate in the main study. To assess their current nutritional status they will be interviewed and weighed by the research dietitian and asked to keep two 2-day dietary records and to donate two finger prick blood samples. The children will be seen by the dietitian a total of three times: one 20-minute interview and two 10-minute interviews.

We will allow only those children with written parental consent to participate in any part of this study. The identity of the school and of the children and their parents will remain completely confidential. The results of the study will be presented to the school following analysis of all the data collected and we will inform the parents and GP of any child found to be lacking in iron.

If you would like any further information please do not hesitate to contact me at 087-2837933. I will follow up this letter with a telephone call in a few days time to discuss the study and to find out if you would like your school to participate. Looking forward to talking to you

Yours sincerely,

Anne Griffin,
Research Dietitian,
Medicine,
Kevin St. D.I.T.

Dr. M.A.T. Flynn,
Dept. of Clinical

St. James's Hospital.

Dr. N.P. Kennedy,
Dept. of Clincal Medicine,
St. James's Hospital.

Appendix A.2

Consent form

THE EATING HABITS OF IRISH GIRLS AND BOYS.

A study being carried out jointly by the Department of Biological Sciences, Kevin St., College of Technology and the Department of Clinical Medicine, Trinity Centre for Health Sciences, St. James's Hospital.

Date: 28 Sept. 1998

Dear Parent/Guardian,

Adolescence is a time when children need good food intakes because they are growing very quickly. Research has shown that children can lack iron and other vitamins during this time. We want to find out how these problems might affect Irish children.

We would be grateful if your child would help us in this work by allowing us to measure his/her food intake (through an interview with a dietitian), to assess his/her ideas about food (using a questionnaire) and to measure his/her blood level of iron (using finger prick blood sample). A dentist will also examine his/her teeth. This study will help Irish children to choose which foods they need to be healthy.

If you would like your child to be included in this pilot study please sign this form and return it to the class teacher. The names of all children and schools will be kept strictly confidential. We will inform the parents and the GP of any child found to be lacking in iron. The overall findings of the study will be given to the school. If you have any questions you would like to ask about the study please contact Anne Griffin at 4024656 or 087-2837933.

Sincerely,

Anne Griffin,
Dietitian.
Dublin Institute of Technology.

Dr. Mary Flynn,
Lecturer in Human Nutrition and Dietetics,
Dublin Institute of Technology.

I would like my child to be included in "The Eating Habits of Irish Girls and Boys" study.

Child's signature:.................................... Date of Birth..........................

Parent/Guardians signature:...

Address:...
....
....

Telephone No:........................... Name of GP: ....

Date:......................

Appendix A.3

Self-report questionnaire

Questionnaire

Part A

1. Subject number

2. When is your birthday?

____

3. What is your age?

____

Part B

4. How often would you do the following?

(I) How often do you watch TV/video/play computer games?

(Circle your answer)

EVERYDAY

5 TO 6 DAYS A WEEK

3 TO 4 DAYS A WEEK

LESS THAN ONCE A WEEK

DON'T KNOW

NEVER

1 TO 2 DAYS A WEEK

(II) How long do you spend watching TV/videos/play computer games each day?

(Circle your answer)

DON'T KNOW

5 TO 6 HOURS

0 TO 2 HOURS

3 TO 4 HOURS

NONE OF THE ABOVE

(III) How often do you read a book?

(Circle your answer)

EVERYDAY

5 TO 6 DAYS A WEEK

1 TO 2 DAYS A WEEK

3 TO 4 DAYS A WEEK

LESS THAN ONCE A WEEK

DON'T KNOW

NEVER

(IV) How long do you read for each day?

(Circle your answer)

5 TO 6 HOURS

3 TO 4 HOURS

NONE OF THE ABOVE

0 TO 2 HOURS

DON'T KNOW

Part C

5. Thinking about your teeth ...

(i) Did you ever have toothache?

(Circle your answer)

YES NO DON'T KNOW

(ii) Did you ever have a tooth taken out by the dentist because it was bad?

(Circle your answer)

YES NO DON'T KNOW

(iii) Did you ever have a tooth abscess?

(Circle your answer)

YES NO DON'T KNOW

(iv) Do you have any fillings?

(Circle your answer)

YES NO DON'T KNOW

(v) How much toothpaste should you put on your toothbrush?

(Circle your answer)

Cover the whole brush | None | The size of a pea

(vi) How often do you go to the dentist? *(Circle your answer)*

NEVER

ONLY WHEN I AM IN PAIN

DON'T KNOW

HARDLY EVER

TWO TIMES A YEAR

EVERY TWO YEARS

ONCE A YEAR

(vii) How often do you brush you teeth? *(Circle your answer)*

MORNING AND NIGHT

DON'T KNOW

EVERY MORNING

EVERY NIGHT

AFTER EVERY MEAL

LESS THAN ONCE A DAY

NEVER

6. Please circle the answer to these statements:

Example:

Fruit and vegetables contain lots of vitamins

$\boxed{\text{TRUE}}$	FALSE	DON'T KNOW

(i) Sugar will provide instant energy for sport

TRUE	FALSE	DON'T KNOW

(ii) Sweets eaten several times during the day will cause bad teeth

TRUE	FALSE	DON'T KNOW

(iii) Sugar makes you fat

TRUE	FALSE	DON'T KNOW

7. What do you think of the food that you eat everyday?

(Circle your answer)

HEALTHY

BOTH HEALTHY AND UNHEALTHY

UNHEALTHY

8. Are you happy with the food that you eat every day?

(Circle your answer)

YES NO DON'T KNOW

9. Have you ever tried to change the food that you eat?

(Circle your answer)

YES NO DON'T KNOW

10. How do you find out what foods are good for you to eat?

(Put a tick (✓) in the box next to your answer or answers.)

- Parents/Guardians ☐
- Friends ☐
- Magazines ☐
- Shops/Supermarket ☐
- TV/Radio ☐
- Doctor ☐
- Dentist ☐
- Teacher ☐
- Other : ☐

Please say where else you think you would find out what you should be eating? ______________________________

____

____

____

11. If you had £1, what would you buy with it?

____

____

____

____

Part D

12. Have you ever thought you would like to be :

(Put a tick (✓) in the box next to your answer or answers.)

Taller than you are now ❑

Smaller than you are now ❑

The same height you are now ❑

13. Have you ever thought you would like to be :

(Put a tick (✓) in the box next to your answer or answers.)

Heavier than you are now ❑

Lighter than you are now ❑

The same weight you are now ❑

14. Have you ever tried to change the shape of your body?

(Circle your answer)

YES NO DON'T KNOW

15. Have you ever tried to put on weight?

(Circle your answer)

YES NO DON'T KNOW

16. If you circled YES which of these ways did you use to put on weight?

If you circled NO which of these ways would you use to put on weight?

(Put a tick (✓) in the box next to your answer or answers.)

- Eat more of the same food that I eat now ☐
- Eat more sugary food e.g. jam, toffees ☐
- Eat more fatty food e.g. chips, chocolate ☐
- Talk to a doctor ☐
- None of the above ☐
- Other (please say how): ☐

____

____

____

17. Have you ever tried to lose weight?

(Circle your answer)

YES NO DON'T KNOW

18. If you circled YES which of these ways did you use to lose weight?

If you circled NO which of these ways would you use to lose weight?

(Put a tick (✓) in the box next to your answer or answers.)

- Skip meals ❑
- Eat less sugary foods e.g. jam, wine gums ❑
- Eat less fatty foods e.g. chocolate, chips ❑
- Eat less meat ❑
- Drink less milk ❑
- Drink more water ❑
- Make yourself sick ❑
- Do more exercise ❑
- Use special diet tablets ❑
- Other (please say how): ❑

____

____

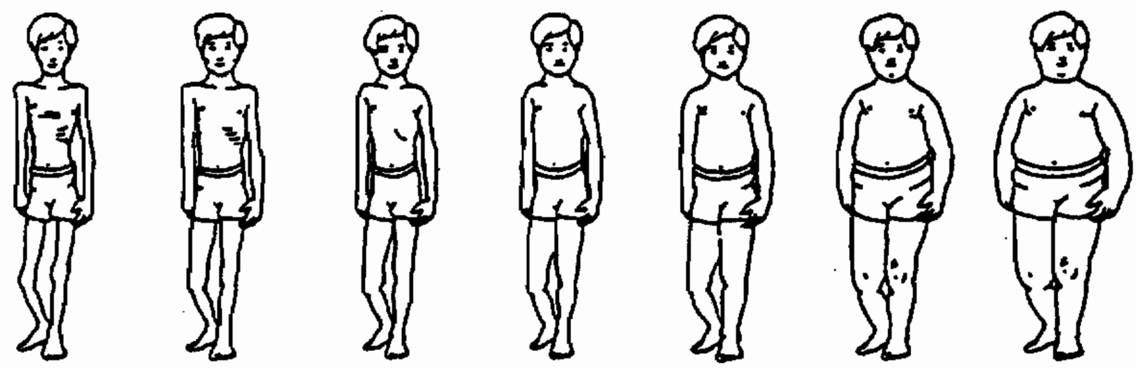
____

____

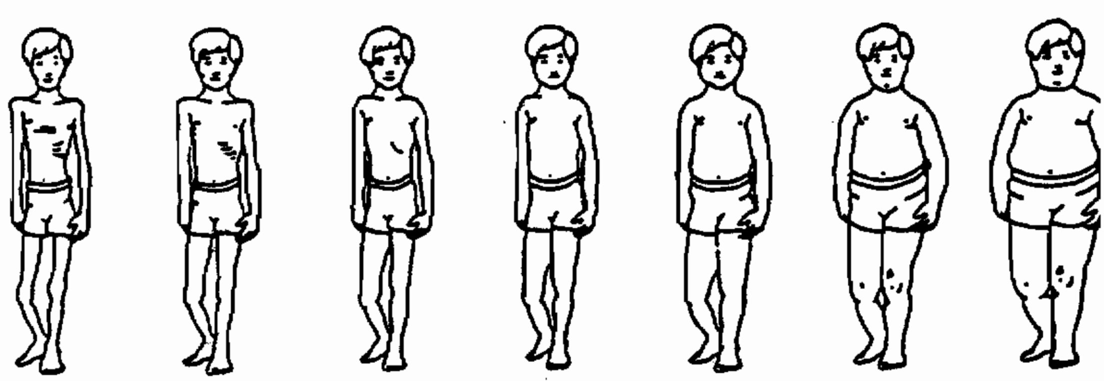
19. *(Using the pictures drawn below)*

Thinking about the shape of your body...

(i) Which one looks most like you?

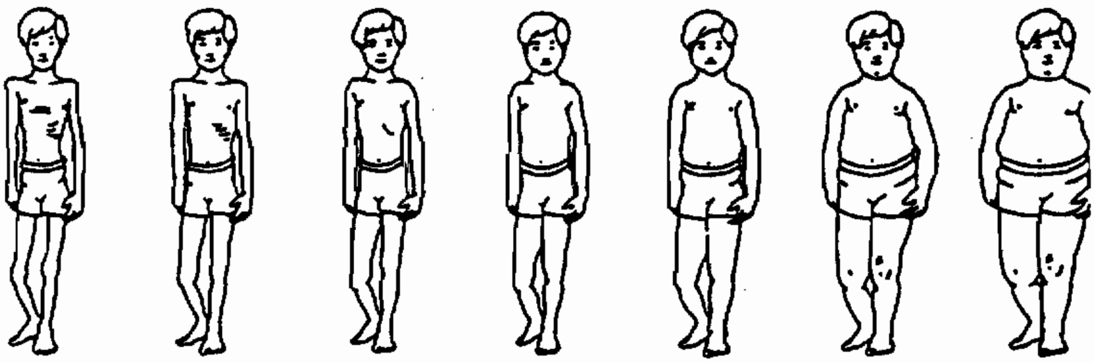


(ii) Which one would you like to look like most?

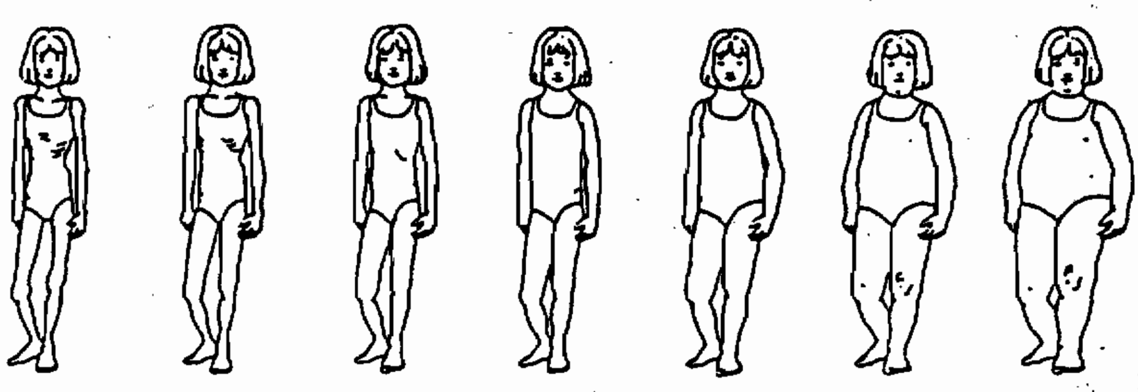


12

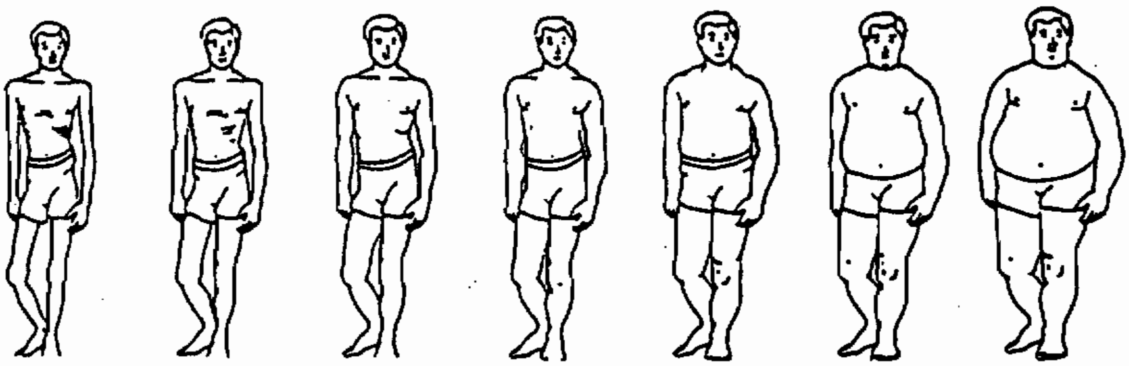
(iii) Which one do you think a girl would like the most?



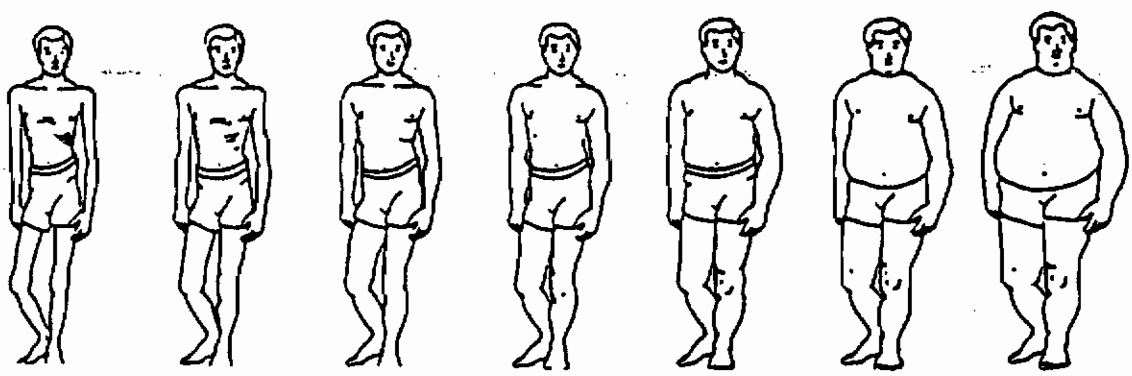
(iv) Which girl do you like the most?



(v) Which one will you look like when you grow up?



(vi) Which one would you like to look like when you grow up?



A.4

Script accompanying self-report questionnaire.

Questionnaire – Script

Thank you all very much for agreeing to be part of this nutrition study. This questionnaire will only take about fifteen minutes to fill out. I will work through it and explain each question to you using this overhead projector. Please stay on the same question as is being shown on the screen and do not skip ahead. **Remember there are no right or wrong answers – I want to know what you yourself think, what your own opinion is of what is being asked.** No one else except for me will ever see your answers. Also you all have your own identity number on the questionnaire so I won't even know whose is whose. You won't get into trouble for the answers you give.

Q1: This is your identity number that I mentioned earlier. You do not have to write in anything here.

Q2: When is your birthday? I want you to write down what date your birthday is on this year, for example mine is the fourteenth of December 1998.

Q3: What is your age? I want you to tell me what age you are now. That is what age were you on your last birthday. I **do not** want to know what age you will be on your next birthday…only the age that you are now, today.

Q4: (i) How often do you watch TV/videos/ play computer games? As you can see there are loads of answers scattered on the page under this question. I want you to circle your answer. For example, if you think you hardly ever watch TV and videos and play computer games than circle an answer that tells me this like LESS THAN ONCE A WEEK.

(ii) For how long do you watch TV/videos/play computer games every day? Again, you have lots of answers to choose from. Think about what programmes you watch on TV every day and every night and how long each of them lasts. Think, as well, of whether you would watch a video or of how many hours you would usually, in a day, play computer games. So, if you watch TV/videos or play computer games everyday for hours and hours on end circle the answer that tells me this 4 – 6 HOURS.

(iii) How often do you read a book? This doesn't mean your books while you are in school. I want to know how often you would sit down at home and read a book, a comic, a magazine or a paper for example. Again you have loads of answers to choose from so look at them all carefully and pick out which one best tells me how often you like to read.

(iv) For how long would you read a book for each day? Maybe you only read before you go to bed, maybe you prefer reading instead of watching TV or maybe you never read books, magazines, comics' etc. except for those books you read in school. Tell me how many hours you think you read for outside of school on a typical day.

Q5: (i) The next section asks you questions about your teeth and going to the dentist. The first question asks you if you have ever had a toothache. If you have circle YES, if you never have circle NO and if you are not sure if you have ever had toothache then circle DON'T KNOW.

(ii) Have you ever had a tooth taken out because it was bad? In other words has your dentist ever taken out one or more of your teeth because they were bad (he would probably have told you it was bad) and not just because he was making way for new teeth coming up or for fitting a brace. If you have circle YES, if you never have circle NO and if you are not sure if you have ever had a tooth taken out because it was bad then circle DON'T KNOW.

(iii) Have you ever had a tooth abscess? This is not the same as a gumboil. It is a very sore pain in your tooth that will not go away and you have to go to the dentist to cure the pain. He will usually give you medicine to fix it. If you have circle YES, if you never have circle NO and if you are not sure if you have ever had a tooth abscess then circle DON'T KNOW.

(iv) Do you have any fillings? If you have circle YES, if you have none circle NO and if you are not sure whether you have fillings in your teeth or not circle DON'T KNOW.

(v) How much toothpaste should you put on your toothbrush? There are three different answers to choose from here. Either you should cover the whole brush, use no toothpaste at all or the toothpaste you put onto your brush should be the size of a pea. You choose which is the correct answer and circle it.

(vi) How often do you go to the dentist? There are seven choices given to you here. Take a minute to read all the different answers and circle the one which applies to you....maybe you have never been to the dentist, or maybe you go a couple of times a year. I only want to know about the regular dentist and **NOT** about how often you may be visiting the orthodontist, that is the dentist who sorts out braces for your teeth.

(vii) Do you brush your teeth? Again, you have loads of answers to choose from. What I want to know are how many times a day do you each brush your teeth. Circle your answer.

Q.6 These next three questions are to be marked as true, false or that you don't know. For example, fruit and vegetables contain lots of vitamins. You can see that true has a circle around it because fruit and vegetables do contain lots of vitamins.

(i) The first one asks you if sugar will provide instant energy for sport. Please circle if you think this is true, false or if you don't know.
(ii) Sweets eaten several times during the day will cause bad teeth. Is this true or false or do you know?
(iii) Sugar makes you fat. Please circle true, false or don't know.

Q.7 The next few questions deal with what you eat every day, that is your diet. So, what do you think of the food that you eat everyday? Do you consider it as healthy, both healthy and unhealthy or do you think that all you eat everyday is unhealthy food? Circle your answer.

Q.8 Are you happy with the foods that you eat everyday? Just circle yes, no or don't know.

Q.9 Have you ever tried to change the foods that you eat? For example, maybe at some stage you made an effort to eat more fruit and vegetables. For this question ignore what you might do for Lent, e.g. Giving up sweets. I just want to know if you ever decided yourself for your own reasons to change something about your diet. Circle yes, no or don't know.

Q. 10 How do you find out what foods are good for you to eat? I have given you some choices here including your parents/guardians; friends; magazines; shop/supermarkets; TV/radio; doctors; dentists or teachers. Tick which of these people or places you would use to find out what is good for you to eat. Or, if you think you wouldn't use any of these or you think of somewhere else besides the choices I have given you write in your own answer in the space provided.

Q.11 If you had one pound to spend, what would you decide to spend it on, if you would spend it at all? There is plenty of space provided for you to write your answer but remember it is only one pound and not any more than that, so what would you do with it?

Q.12 The following questions are all to do with what you look like. The first one asks you if you have ever thought you would like to be taller, smaller or the same height you are now? Put a tick beside your answer.

Q.13 The next question asks if you have ever thought that you might like to be heavier, lighter or the same weight that you are now?

Q. 14 Have you ever tried to change the shape of your body? For example, maybe you decided to do more exercises to build up your muscles, maybe you have gone on diets, or maybe you have eaten more food than usual because you thought you were too thin? Maybe you have never thought about it one way or the other. Circle your answer, yes if you have tried to change the shape of your body, no if you haven't and don't know if you are not sure whether or not you have ever tried to change your body shape.

Q.15 Have you ever tried to put on weight? Circle yes, no or don't know.

Q.16 If you circled yes meaning that you have tried to put on weight then I want to know how you tried to put on your extra weight. There are a few choices of ways you might have tried listed on the page but if you didn't use any of these then write in the space provided how you tried to put on your extra weight. If, however, you circled no that you have never tried to put on weight then I want to know how do you think you would go about putting on extra weight if you ever decided you needed to. You can choose from the answers listed as well or use the space provided to write out your answer.

Q.17 Have you ever tried to lose weight? Circle yes, no or don't know.

Q.18 Again, if you circled yes that you have tried to lose weight I want to know how you tried to lose it and there is a list of different ways some people use on the page in front of you. If you did not use any of these ways then write out in the space provided how you tried to lose weight. If you circled no or don't know that you have never tried to lose weight then I want you to think about how you would go about it if you ever did decide to lose weight. Again, you too can use the space provided if you come up with a different way you would lose weight than what is written on the page.

Q.19 In this section you must circle one person in the line of pictures as your answer.

(i) Thinking of the shape of your body which child in the pictures looks most like you do at the moment. Circle your answer.

(ii) Again, thinking of your body shape which of the children in the picture would you like to look like the most. Circle your answer.

(iii) I'm talking to the boys now just for the moment…which of the pictures of the different body shapes of the boys do you think girls of your age would prefer. Circle your answer.

(iv) And which picture of the different shapes of the girls do you prefer? Circle your answer.

(v) I'm talking to the girls now …which of the pictures of the different body shapes of the girls do you think boys of your age would prefer. Circle your answer.

(vi) And which picture of the different shapes of the boys do you prefer? Circle your answer.

(vii) Now everybody look at the next page and the first set of pictures and circle for me which of the adult pictures you think is the same shape as you will be when you grow up?

(viii) Finally everybody look at the second set of pictures and circle for me which of the adult pictures you would like to look like when you grow up. That is which shape would you prefer to be when you are an adult.

Appendix A. 5

Interview-assisted questionnaire.

Interview questionnaire:

1. Subject Number: Subj id

Age

2. Date of birth:
3. Age on last birthday: Age years

Gender

4. Girl
   Boy

Gender
1= girl
2= boy

Social class

5. Does your father work?
   YES NO DON'T KNOW
6. What does he work as?

SEC, where
Sec1= 1+2
Sec2= 3+4
Sec3= 5+6

7. Does your mother work?
   YES NO DON'T KNOW
8. What does she work as?

Supplements

9. Do you take any vitamin or mineral supplements?
   YES NO DON'T KNOW

Vitasc

10. Which supplement do you take?

Type:

2

11. How many supplements do you take?

Frequency of use:

ONE A DAY	1
ONE A WEEK	2
ONLY WHEN I THINK OF IT	3
OTHER	4+

12. Have you ever seen a dietitian?

YES NO DON'T KNOW

Dietitian:

13. Do you have any food "allergies"?

YES NO DON'T KNOW

Allergy;

Activity level

14. Do you exercise (so that you feel out of breath or sweaty)?

YES NO DON'T KNOW

Exercise:

15. What type of exercise do you do?

(Tick appropriate box)

Type

- football
- basketball
- hurling
- dancing
- swimming
- roller blading
- table tennis
- running
- tennis
- cycling
- 'other'

16. How many days a week would you exercise on?

Frequency of exercise:

Less then one day	1
One to two days	2
Three to four days	3
Five to six days	4
More than six days	5

17. How long do you spend exercising per day?

Duration of exercise:

Don't exercise	1
Less than a half an hour	2
About one hour	3
About one to two hours	4
About two to three hours	5
More than four hours	6

Pocket money

18. Do you get pocket money?
YES NO DON'T KNOW

Pocket money:

19. How often do you get pocket money?

Frequency of receiving:

Never	1
Once a week	2
Twice a week	3
Every day	4
Once a month	5

Cont.

Less than once a Month — 6

20. How much pocket money do you get at a time?

1 = None
2 = Less than £1
3 = Between £1-£3
4 = Between £3-£5
5 = More than £5

Amount:

21. Are you allowed to spend it as you like?

YES NO DON'T KNOW

Allowance:

22. What do you spend it on?

Spending:

Sweets eg, penny sweets
Chocolate Bars eg. Mars, Snickers
Fruit or fruit juices
Minerals eg. Coke, Fanta
Comics, magazines etc
Take away food
Ice-cream eg. Cornetto, Magnum
Ice-pops eg. Mr. Cool, Fat Frog
Save it

Where a tick is Yes, score = 1; No, score = 2.

Smoking

23. Have you ever smoked?

YES NO DON'T KNOW

Smoking habit

24. Do you smoke now?

YES NO DON'T KNOW

Current

25. How many days a week do you smoke?

Frequency of smoking:

Less than one day	1
One to two days	2
Three to four days	3
Five to six days	4
More than six days	5

26. How many cigarettes do you smoke in a day?

No. of cigarettes:

Less than one	1
1 to 2 cigarettes	2
3 to 4 cigarettes	3
4 to 5 cigarettes	4
More than 5 cigarettes	5

Alcohol

27. Have you ever taken alcohol?

YES NO DON'T KNOW

Drinking habit

6

28. How often would you drink?

	Frequency of drinking:
Less than 1 day	1
1 to 2 days	2
3 to 4 days	3
5 to 6 days	4
Never	5
'other'	6

29. What do you drink?

	Type:
Nothing	1
Cider	2
Lager	3
Spirits	4
Wine	5
'other'	6

30. How much would you drink?

	Amount:
a sip	1
a glass	2
a can	3
a bottle	4
'other'	5

Snacking at home

31. Do you ask permission before helping yourself to a snack at home?

YES NO DON'T KNOW

Permission:

7

32. Are you ever told "no, you can't have a snack"?

YES NO DON'T KNOW

No snacks

33. Why would you not be allowed to have a snack when you wanted one?

Reasons

34. Are there any foods you are not allowed as a snack?

Disallowed Snacks:

Sweets eg, penny sweets

Chocolate Bars eg. Mars, Snickers

Fruit or fruit juices

Minerals eg. Coke, Fanta

Comics, magazines etc

Take away food

Ice-cream eg. Cornetto, Magnum

Ice-pops eg. Mr. Cool, Fat Frog

Save it

Where a tick is Yes, score = 1; No, score = 2.

Menstrual details

35. Have you had your period yet?

YES NO DON'T KNOW

Period

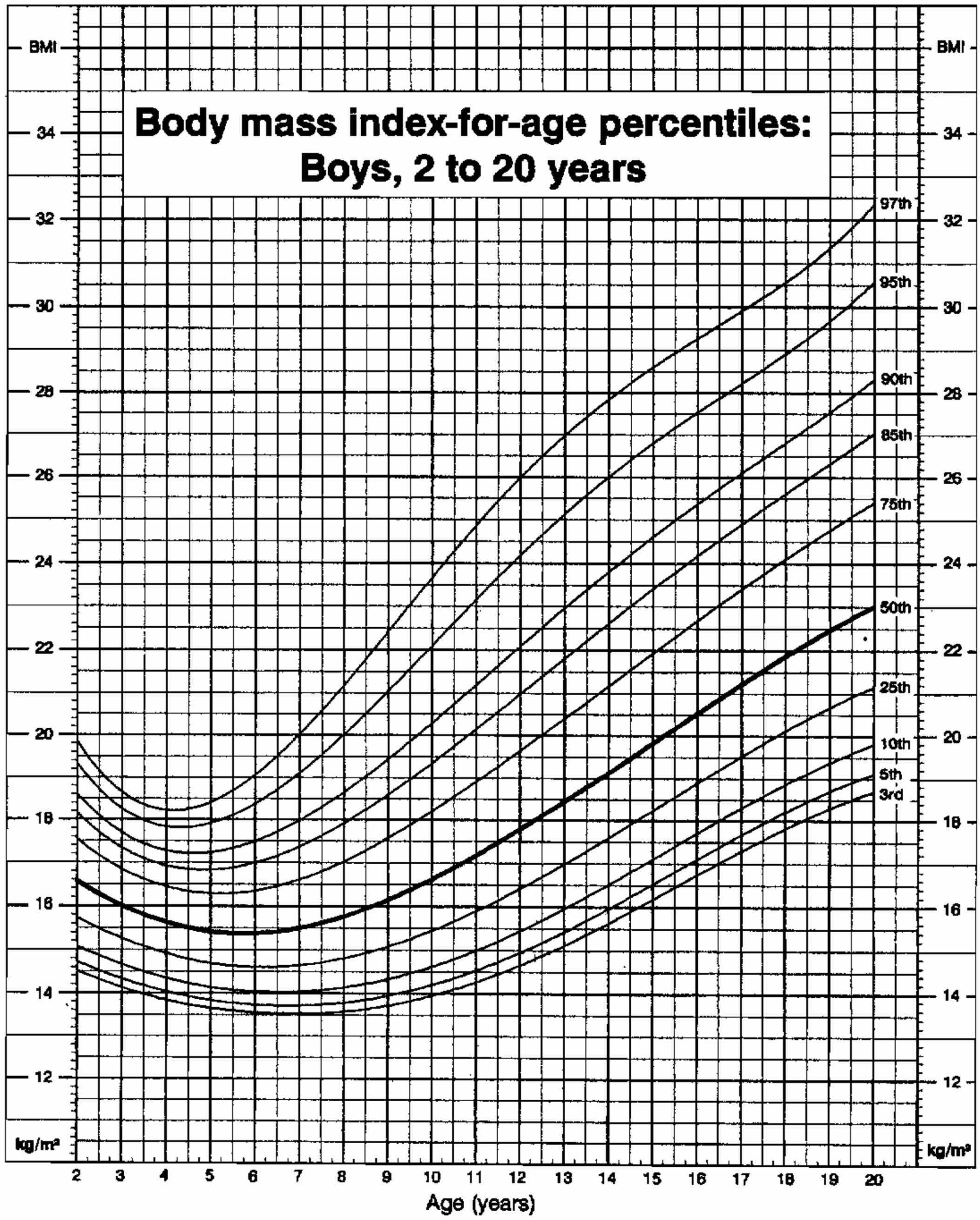
36. What age were you when you had your first period?

Years:

Appendix A.6

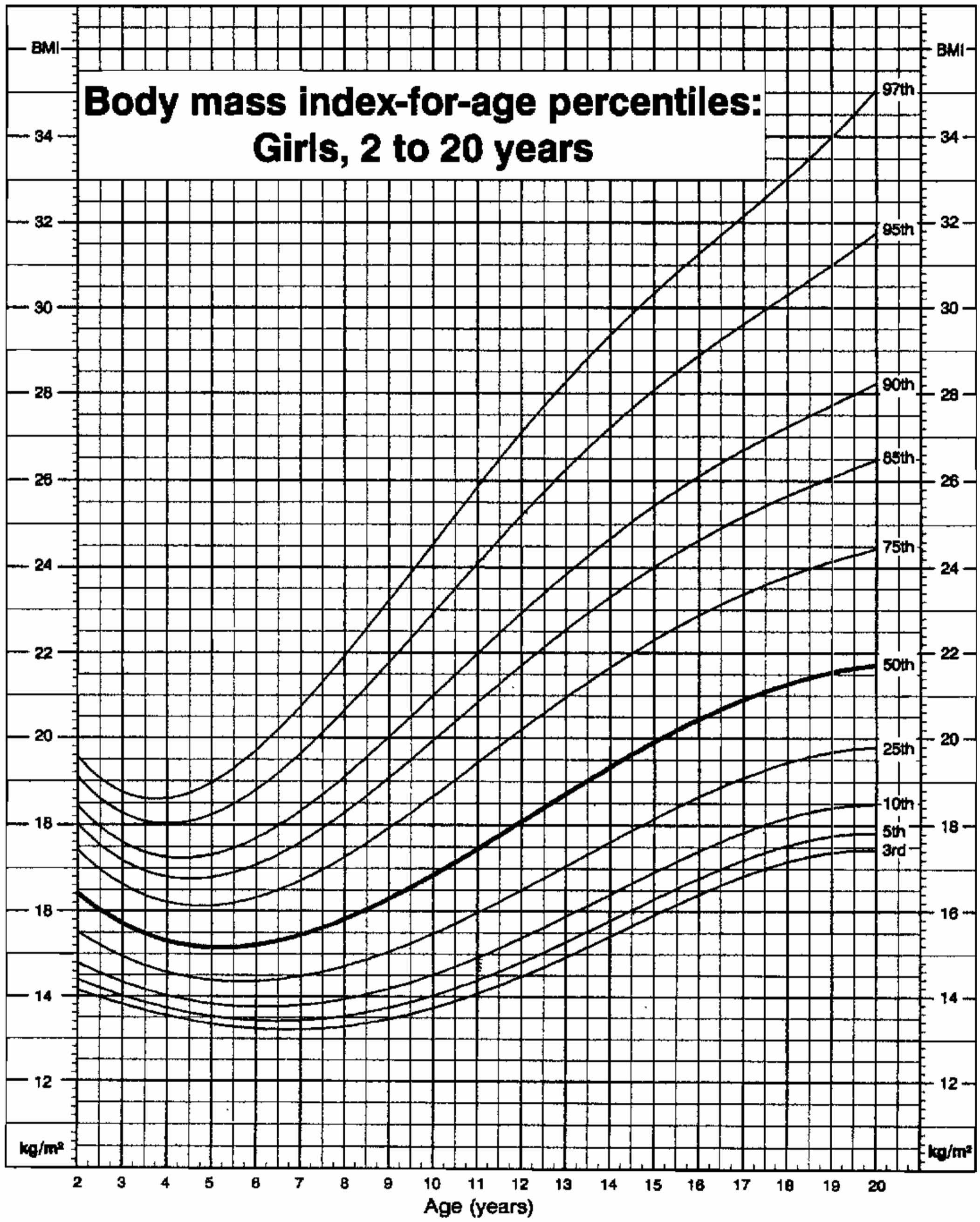
Centre for Disease Control BMI-for-age charts

(Kuczmarski RJ, Ogden CL, Grummer-Strawn LM, Flegal KM, Guo SS, Wei R, Curtin LR, Roche AF, Johnson CL. (2000): CDC growth charts: United States. Advance data from vital and health statistics; no.314. Hyattsville, Maryland: National Center for Health Statistics http://www.cdc.gov/nchs/)



SOURCE: Developed by the National Center for Health Statistics in collaboration with the National Center for Chronic Disease Prevention and Health Promotion (2000).

Figure 15. Body mass index-for-age percentiles, boys, 2 to 20 years, CDC growth charts: United States



SOURCE: Developed by the National Center for Health Statistics in collaboration with the National Center for Chronic Disease Prevention and Health Promotion (2000).

Figure 16. Body mass index-for-age percentiles, girls, 2 to 20 years, CDC growth charts: United States

Appendix A.7

Anthropometry calculations.

Anthropmetrical measurements and details of blood collection:

Subject number: _________

Date of Birth: __ __/__ __/__ __

Male / Female

....

Date of measurements: __ __/__ __/__ __

Weight: ______kg / ______st., ______lbs.

Height: ______cms

BMI ______kg/m^2

Percentile weight for age: ______

Percentile height for age: ______

Percentage relative weight: $\frac{\text{Actual weight} \times 100}{\text{Ideal weight for height, age and sex}}$

Answer: _______%

Five weight categories will be defined (Mellin, 1992):

i. % relative weight < 80%= 'very underweight'

ii. 80-89% relative weight = 'slightly underweight'

iii. 90-110%relative weight = 'normal weight'

iv. 111-120% relative weight = 'slightly overweight'

v. % relative weight >120% = 'very overweight' **Category:**______

....

<u>Skinfold measurements:</u>

Mean arm circumference : ________cm/________mm

Triceps : 1.________mm

2.________mm Average:_______mm

3.________mm **Percentile**:_______

Subscapular : 1.________mm

2.________mm Average______mm

3.________mm **Percentile**

Calculations:

Mid-arm muscle circumference(cm) = Mid-upper arm circumference(cm) – 0.3142 x Triceps (mm)

(MAMC) (MUAC)

Answer:______cm

Percentile of MAMC:______

$$\text{Mid-arm muscle area}(mm^2) = \frac{(\text{MUAC}(mm) - 0.3142 \times \text{Triceps})^2}{4 \times 0.3142}$$

(AMA)

Answer:______mm^2

Percentile of AMA:______

Where:

T = Triceps skinfold thickness (mm)

C = MUAC (mm)

Pi = 3.14

4 x pi = 12.56

All measurements should be done on the right side of the body.

Hold the arm at a 90° angle with palm upwards.

Mark the mid-point (between the acromial and olecranon processes of the scapula and ulna respectively.

Measure the mid-arm circumference with the arm hanging relaxed at the patient's side.

Waist:______cm

Hip:_______cm

Waist:Hip ratio:______

Hip measurements are made horizontally over the widest circumference over the buttocks or trochanters.

Waist measurements are made horixontally midway between the lower rib margin (costal margin) and the superior anterior iliac spine (iliac margin)

Blood sampling:

Date of collection:__ __ / __ __ / __ __

Date of FBC measurement: __ __ / __ __ / __ __

Date of RCF measurement: __ __ / __ __ / __ __

Date of SF measurement: __ __/ __ __ / __ __

Full Blood Count results:

WBC ______x $10^3/\mu l$

RBC ______x $10^6/\mu l$

HGB ______ g/dl

HCT ______%

RDW-CV ______%

MCV ______fl

MCH ______pg

MCHC ______g/dl

PLT ______x $10^3/\mu l$

Serum ferritin results:

Red cell folate results:

Appendix A.8

The Food Diary

Food Diary

Subject Number

Please read instructions carefully!

(Contact number 087-2837933)

HOW TO FILL IN YOUR FOOD DIARY

METHOD OF COOKING - Please ask whoever cooked your food how they did this, e.g. deep-fried; boiled; roasted; microwaved; toasted etc.

BRAND - the name of the company that made your food, e.g. Kelloggs, Dennys, St. Bernard etc.

Code - I will fill in this when I meet you again.

Leftovers - write down the amount and name of any food or drink that you do not finish, e.g. half a potato; four squares of a Cadburys bar of chocolate; half a sandwich, etc.

Please collect and bring in the wrappers or boxes of any food or drink you take over the two days, e.g. ice-cream wrapper, coke bottle, juice carton, etc.

HOW TO FILL IN YOUR FOOD DIARY

Please keep your food diary for the next 2 full days.

Remember !

* ⭑ Don't change the way you eat.
* ⭑ Bring this diary with you EVERYWHERE
* ⭑ Write down absolutely EVERYTHING you eat or drink for the two days, even water
* ⭑ *Start a new page every time you have something to eat or drink.*

This is how you fill out your food diary:

Day and Date – the day of the week, e.g. Monday and the date.

Time – write down the time you eat or drink anything, even if it's only a biscuit or a jelly tot!

Place – write down the place you are in when you eat or drink something, e.g. at home; at the shop; at relatives house; etc.

An example of how to fill in your food diary

Date..................Day...................Time...............Place...........................Meal/Snack

Amount	Food/Drink	Description	Brand	Cooking Method	Code	Weight
Leftovers						

Please fill in the following:

- What is the name of the milk you use at home?

....

- Is this milk low fat? Yes / No
  (Circle your answer)
- Does it have any of these vitamins or minerals added? (It will say so on the carton.)
  (Circle your answer)

Calcium Riboflavin Vitamin ABDE Folic Acid

Parents/Guardians, please answer the following:

- Have you checked through this food diary with your child? (Circle your answer) Yes / No
- Have you included any recipes?
  (Circle your answer) Yes / No
- Any comments?...

....

....

....

Signature:

What is the name of the butter or margarine you use at home?

....

- Is it described as low fat or light? Yes / No
  (Circle your answer)
- Do you take vitamin or mineral supplements?
  (Circle your answer)
  Yes / No
- What is the name of the supplement?

....

- How often do you take it?

....

Appendix A.9

Letter addressed to parents/guardians regarding food diary.

THE EATING HABITS OF IRISH GIRLS AND BOYS.
A study being carried out jointly by the Department of Biological Sciences, Kevin St., College of Technology and the Department of Clinical Medicine, Trinity Centre for Health Sciences, St. James's Hospital.

Date: November 1998

Dear Parents/Guardians,

Thank you for allowing your child to take part in this Nutrition Study. All the information we gather from this study will help us to see if the foods that children are eating are full of the important vitamins and minerals they need to grow properly.

Your child has to keep a food diary for the next two days. He/she will be writing down absolutely everything they eat/drink during this time. I have also asked the children to collect the labels and wrappers from items of food/drink that they take over these two days. As you can understand, there are many different kinds of the food/drink children take and by collecting these items I can know exactly what kind your child prefers.

Your child should keep his/her food diary all by themselves. This will make sure that they don't leave out anything they eat/drink outside of home. In some cases, however, the child may need to ask you about the food they get at home, for example, what kind of meat and what vegetables you added to their dinner. I hope this does not take up too much of your time.

The last page of your child's food diary contains a few questions directed to you personally. Please could you answer these and sign your signature where indicated before the food diary is returned to me.

Thank you again for your kind co-operation.

Yours sincerely,

Anne Griffin,
Research Nutritionist.